THE
PRACTICAL MAGAZINE

NEW SERIES.—No. 23. VOL. 6, 1876.

SIR WILLIAM THOMSON, F.R.S., LL.D., D.C.L.

EVERY age has for the historian some distinguishing principle by which it can be individualized, so to speak; and this age is likely to be known as the period when the fences which before surrounded the various domains of intellectual life have been broken down and the enclosures thrown open to the influences of each other. Whether we observe the existing conditions of theological knowledge, or the scientific, or the mechanical, or the speculative, the remark is obviously correct. The monopoly of creed, phrase, style, and abstract thought has shared the fate of politics: protection is destroyed, and in consequence there exists a period of transition. In the departments of mathematical science and natural philosophy Sir William Thomson occupies probably the most distinguished place among the men of our generation, and it is with much regret that the limits of this paper must be restricted to a bare outline,—so multifarious and influential have been the contributions this great scholar has made to the common stock of knowledge, and to the method of communicating the difficult matters and principles of which he is master to the advancement of general culture.

Ireland has the honour of claiming him as a son. His father, Dr. James Thomson, held the position of mathematical lecturer at the Royal Institution of Belfast in 1824, when his son William was born; but on obtaining the appointment of Professor of Mathematics at Glasgow University, in 1832, he removed to that city. In 1845, at the age of twenty-one, William graduated at St. Peter's, Cambridge, when Harvey Goodwin (the present Bishop of Durham) was Moderator, and came off first Wrangler and first Smith's Prizeman, obtaining, in 1846, the position of Professor of Natural Philosophy in the University of Glasgow, and was made Fellow of his College, which he held until 1852. Mr. Ellis having ceased to edit the "Cambridge Mathematical Journal," Mr. Thomson commenced a new series, entitled the "Cambridge and Dublin Mathematical Journal," and during the six years, 1846 to 1851, contributed several mathematical notes and papers, besides some articles on electricity and kindred subjects; he also wrote an important one in Liouville's "Journal de Mathématiques," vol. x. p. 209, which he reprinted here with considerable additions, entitled, "On the Mathematical Theory of Electricity in Equilibrium," wherein he set forth the "Elementary Laws of Statical Electricity," as expounded by Coulomb and objected to by Mr. Snow Harris and Mr. Faraday. This he followed, in 1848, by a "Statement of Principles on which the Mathematical Theory is propounded," and "Geometrical Investigations with reference to the Distribution of Electricity on Spherical Conductors," the last chapters appearing in 1849-50, and in all making one series of six papers.

The unwearying industry which is his characteristic prompted

him to write more than a hundred times to the learned societies, and all his communications are much esteemed. To the British, on electricity, on the currents by which terrestrial magnetism may be produced, on the equilibrium of magnetic bodies under the influence of the terrestrial magnetic force, on the theory of magnetic induction in crystalline substances, on the sources of heat generated by the galvanic battery, several on magnetism in various phases, experimental researches on thermo-electricity, on the use of observations of terrestrial temperature for the investigation of absolute dates in geology, on the electric qualities of magnetized iron, the thermo-electric position of aluminium, on peristaltic induction of electric currents in submarine telegraph wires, on machinery for laying submarine telegraph cables and other branch subjects connected with sea telegraphy. This small list is but a selection, but it must suffice. The Transactions of the Royal Societies of London and Edinburgh, and the Philosophical of London, and the Royal Astronomical, include more than an equal number and of kindred interest. The irresistible force with which he applies his acquirements in mathematics undoubtedly has given him the almost universal confidence of the intellectual world, which the daring nature of his announcements and statements would have made difficult of appreciation under other conditions.

We purpose to notice now his practical connection with the Atlantic Cable construction, on account of which he received, in 1866, the honour of knighthood, and preceding investigations and work in the same field led him to the construction of many valuable instruments, such as electrometers and galvanometers, &c.; for it is the remarkable combination of mechanician, philosopher, and engineer, which that study showed him to possess, that qualified him to be as positive as a practical man as he was cogent in his mathematical deductions.

So long back as 1845 Professor Thomson issued (contributed, we may say,) his first advance in the mathematical theory of electricity. Mr. Green, a self-taught mathematician, had propounded the same in 1828, but his labour failed to attract the notice of scientific people, and his general theorems were rediscovered by Thomson, the brothers Sturm of Paris, and Gauss of Gottingen; but the first of these pushed his researches the farthest. He pointed out the consistency of Faraday's experiments with the new theory; and, guided by an analogy between the uniform motion of heat and the distribution of electricity on conductors, showing how the electric polarisation in dielectrics discovered by Faraday is to be taken into account in the theory of the Leyden phial, supplied the deficiency in Green's investigations. From this Thomson was led to the beautiful principle of what he calls "electric images and reflections," which he described before the British Association in 1847, and is in the Transactions of that body to which we have already referred. He invented a galvanometer superior to all preceding it, by being simple, inexpensive, and producing clearer results. He takes a mirror whose weight does not exceed a few grains, and whose momentum is therefore very small, and in dispensing with the telescope Weber adopted, throws a spot of light directly upon the scale, lessening its distance. For all measurements in which the instrument serves as a galvanoscope, as in Wheatstone's bridge, &c., it is much to be preferred.

In 1861, he wrote a paper, "An explanation of the true and false discharge of a coiled electric cable, showing that the second current—the false—was attributable to mutual electromagnetic induction between different parts of the coil." Mr. Jenkin proved his statement by experiments, and in 1862, read to the Royal Society the result in a paper "On the laws of transmission of electric signals through submarine cables." Thomson, in 1845, published his "Theory of the Electric Telegraph," and it made his reputation as one of the band of eminent men who were determined to solve the innumerable problems that continually cropped up in that marvellous enterprise, towards the solution of which he made many contributions. In 1858 he patented his "Improvements in testing and working electric telegraphs;" and in the same year he displayed his engineering power in his patent for "Improvements in apparatus for applying and measuring resistance to the motion of rotating wheels, or other bodies, with especial reference to the laying of submarine cables;" it was, in fact, a regulator, without which the Atlantic Cable would never have been laid. Then, in 1860, his patent in connection with Mr. Jenkin, entitled, "Improvements in the means of telegraphic communication," by which the contacts used to send signals through submarine lines are adjusted in such a manner that the final strength caused by each signal at the receiving end of the conducting wire shall be constant, and "that during the interval separating successive letters, &c., the current shall remain in constant strength;" these increased the speed of signalling, and ensured regularity. This is a very elaborate patent, occupying twenty sheets, and has drawings.

One has but to glance at the volume he published in 1872, containing the essence of all his printed papers on magnetism and electricity, to see how truly serviceable Sir Wm. Thomson's labours have been to his country, and to cease to wonder that it should have been, amid his many studies, that which led him to social distinction. It will be remembered that the cable of 1865 broke immediately after it had been laid, and that a new one was instantly put in hand. Sir Wm. Thomson's measures for "storing and paying out" prevented a like catastrophe with the second, which was made precisely in the same manner as the former. To the delight of England and the intense gratification of the promoters and labourers it was laid successfully, and a telegram from Gooch to Glass on the morning of Aug. 28th, from Newfoundland, records the thankfulness of all concerned. Messages of congratulation came through from the Queen to Andrew Johnson, the President of the United States, who replied, and from Lord Carnarvon to General Monk, the Governor of Canada. Three days before this happy termination had been effected Her Majesty's ship "Terrible" and the screw steamer "Albany" started to pick up the broken cable, having on board Mr. Gooch, M.P., and Mr. Cyrus Field, Mr. Canning, Mr. Clifford, Professor Thomson, Mr. Deane, and other eminent electric celebrities. On Sunday morning, the 2nd September, the grapnel took hold, after having made fourteen previous attempts. The crew began to haul up at 3·45 p.m. The companion ship took up position to aid at a distance along the line, and in five or six hours telegraphed she had hauled up 500 fathoms; by 12·50 the cable made its appearance on the grapnel amid the profound silence of the whole party. The signal was given to haul, and by dint of great care and toil the cable was attached to the drum of the "Great Eastern," and from the electrician's room news of success flew through the old apparatus to Valentia, and brought back congratulatory replies.

The national pride at this double success made it imperative on the ministry to make a public recognition of the services of those who had most eminently contributed to so gratifying a result, and among these was Professor Thomson, who received from the Queen the honour of knighthood "for his services in furthering the success of the laying of the Atlantic Cable." The example of national distinction was followed by the Oxford University, who in the same year graced him with her D.C.L. degree, in which she was imitated by Cambridge, which conferred upon him the LL.D. He had already received from Dublin in 1857 the same designation, as a mark of the appreciation by that University of the labour and service of another of Ireland's children. The Edinburgh University did itself the honour of bestowing a like degree.

Professor Thomson read a paper, in 1852, at the Glasgow Geological Institute on the Secular Cooling of the Earth, a theory known by some as the Dissipation of Energy. He proceeded upon the fact that the solar system cannot have gone on for millions of years without losing by dissipation a considerable portion of the entire energy on which geological and other forces ultimately depend, and contended that the amount of change which took place formerly upon and within the crust of the earth must have been much greater and more violent than anything within human experience. He used the simile of a monitor in action, and remarked that it is just as certain that the earth must possess less volcanic energy now than at first, as it is that the monitor, after firing away shot and shell for hours, must have less ammunition on board than at the beginning of the battle. In this he claimed the support of Sir Robert Murchison, as against the Uniformitarian writers, and contended for the occurrence of far more powerful movements of upheaval or fracture; and, in addition, claimed the independent evidence from modern physics. Turning to the data of the geologists themselves, he asked:—

"Do not the vast masses of basalt, the general appearance of mountain ranges, the violent distortions and fracture of strata, the great prevalence of metamorphic action (which must have taken place at depths of not many miles, if so much), all agree in demonstrating that the rate of increase of temperature downwards must have been much more rapid, and in rendering it probable that volcanic agency, earthquake shocks, and every kind of so-called plutonic action have been on the whole more abundantly and violently operative in geological antiquity than in the present case?"

There is no doubt of the fundamental truth for which Sir William contended, viz., that there must be less potential energy in the solar system now than there was originally; but much of the argument by which he supported the theory met with sharp discussion, and is still unsettled. Professor Huxley came forward as—to use his term—the geological attorney-general for the time being, to plead against Sir William's charge, "that a great reform in geological speculation seems now to have become necessary." "It is quite certain that a great mistake has been made, that British popular geology at the present time

(1870) is in direct opposition to the principles of natural philosophy." Thomson based his charges on the assumption that the geologist demands unlimited time for the explanation of rock phenomenon, and on the other hand the tidal retardation of the earth, by which its revolution on its axis is checked by the attraction of the sun and moon, renders it impossible that life could have existed more than a hundred million years; and that the sun could not have illuminated the earth much before that date, and that from fifty to three hundred millions of years ago the earth's surface was molten. Such loose theories he exposed. He had a right to do so. Darwin demands three hundred million years for the erosion of the Wealden area between the North and South Downs, and Jukes thought Darwin might justly have multiplied his figures by ten. We revert to this controversy for the sake of merely placing before the reader an illustration of the kind of mind and the extent of power possessed by the learned professor, and not for the sake of taking a part in the controversy. Huxley contended well, but the questions remain undetermined at present, and probably will for many years to come.

The schools of geology may be divided into three: first, Catastrophism,—the doctrine of a past era in geological inquiry; second, Uniformitarianism, that of the present; and third, Evolutionism, that of the future. Of this latter school the numbers are few, but the reputation eminent. The chief leaders are Sir W. Thomson, Dr. Tyndall, Mr. Herbert Spencer, and Professor Huxley. We would like to describe this latter school, but the limits of space forbid. It is enough to say, "So far as our earth is concerned, the only idea we can grasp of it is, that it was a fiery body, like the sun, and that it has been gradually cooling down to the present day." Sir William looks out into the earth's future, and maintains that the rate of its present loss of heat by radiation implies that the time will arrive when, like a meteorite, it will become cold to its very core, and life will cease to be found because of the lowness of temperature, provided that no collisions with other bodies happen to restore the heat which has been lost. He supposes that the light and heat of the sun originated in the arrested motion of cosmical bodies which have fallen into it, and (with other physicists) that these are maintained by the constant gravitation into it of asteroids, meteorites, and planets. All planetary matter is inevitably gravitating towards the sun, which apparently will become the common bourne of our system. "As surely," says Sir William Thomson, "as the weights of a clock run down to their lowest position, from which they can never rise again unless fresh energy is communicated to them from some source not yet exhausted, so surely must planet after planet creep in, age by age, towards the sun; not one can escape its fiery end. In like manner, the satellites of planets must inevitably fall into their respective planets."

We must here pass to another subject. Professor Thomson had appeared before the Royal Society of London to read a paper some few years previous to the delivery of his celebrated Bakerian Lecture, on the Electro-Dynamic Qualities of Metals, and been enrolled a Fellow of that distinguished Association. This Bakerian Lecture won him the Royal Medal. It consists of a series of experimental investigations of the highest value, as necessary, and probably of wider appreciation at the present time as when delivered in February, 1856. This Bakerian Lecture not only includes Professor Thomson's ideas and investigations, but it makes itself into a kind of historical record of the department of science of which it treats. It is too abstruse to bear abridgment, and too long for quotation—almost one hundred pages in the Philosophical Transactions for 1856, and containing many tables and diagrams and the minutiæ of every experiment. The subjects of heat and electricity are daily interweaving, and from the combination knowledge is constantly being evolved; and this renders the detail of past labours most advantageous information to the young student. Indeed, the volume, "Papers on Electro-Statics and Magnetism" is one almost indispensable to a thorough and capable inquirer.

In conjunction with Professor Tait, Sir William Thomson has published a treatise on "Natural Philosophy," which is one of our most important text-books, and illustrates in another form the activity of mind of the author,—an activity in which he has shown himself as eminent as in research.

We have not space to set before our readers the pith of his many communications to the outer world on these topics, in which he appears as the philosopher. He delivered the Bede Lecture at Cambridge in 1866; was President of the British Association at its Edinburgh meeting in 1871; was elected President of the Geological Society of Glasgow for the year 1872; and in the autumn of that year his old college, St. Peter's, Cambridge, conferred on him a fellowship, which it is permitted to do on men eminent for science and learning. He had lost his original fellowship by his marriage in 1852; but the college statutes give power to reconfer that honour on the attainment of special eminence. A recent visit to America gave rise to many pleasant remarks in his opening address as President of the Mathematical and Physical Section at the recent meeting of the British Association, on the scientific institutions and the intercourse with the scientific men of that country.

That he may be satisfied in observing the extension of intellectual and scientific knowledge, and with it freedom; and that the result of his past and future labours may continue to be in favour of so glorious an end, is and must be the desire of every reader of THE PRACTICAL MAGAZINE.

W. S. C.

TECHNICAL EDUCATION FOR THE IRON TRADE.[1]

IN this communication it is not my intention to dwell at any length upon the importance of what is termed "technical education." This importance is now very generally recognized throughout this country; but, in respect to the means available for imparting special scientific instruction bearing upon the various arts and industries, it must be admitted that England does not compare at all favourably with the many other countries which are in close competition with our own manufacturers in the markets of the world. The great hindrance, however, that has hitherto been experienced in dealing with technical education has been the unsatisfactory condition of primary education in England. It is useless to expect a flourishing fruit tree by engrafting upon a weak and worthless stock; and as it is only within the last six years that any successful attempt has been made to establish a broad system of elementary education, we can hardly look for tangible results, as far as the mass of the population is concerned, until the present rising generation grows up. But there can be no doubt that the educational machinery that was available and in operation previous to the passing of the more recent acts was the means of affording a good elementary education along certain lines; its defect was that it did not grapple with the whole field of ignorance. It is to be hoped that this difficulty is now in a fair way of being removed. Turning now to what has been done in providing facilities for imparting technical knowledge, we must not overlook the fact that the matter has by no means been lost sight of or neglected; but we have not yet got so far as several other countries have done. The establishment of the School of Mines in Jermyn Street has been productive of some good results, but it has not accomplished anything like what was originally expected from it. Mining schools have been tried in several of the colliery and mining districts, and have been useful in their way. The Science and Art Department at South Kensington has, however, been successful in organizing an excellent system for imparting a knowledge of elementary science. In order to effect this it has mainly taken advantage of the teaching staff of the primary schools, and by offering inducements in the shape of money grants according to results the foundation has already been laid upon which a good superstructure ought to be built. But, as a general rule, the South Kensington system cannot advance matters beyond the first or elementary stage. It has the effect of imparting the rudiments of technical and scientific knowledge, and sifts out those whose aptitude and inclination would lead them to pursue their studies, provided suitable facilities existed within easy reach. Such youths or men are the cream of what may be termed the upper and intelligent industrial class. They have to earn a living, and cannot, therefore, go to a distant place to follow up their studies; but wherever institutions of the right kind exist, they readily avail themselves of the same. It is unfortunate, however, that comparatively few of such institutions have been established, and of those already organized several have not advanced beyond what may be termed the initiative stage, and are, consequently, only able to furnish technical and scientific education in a limited number of departments. It is with a view of pointing out one way at least in which institutions of this character might be very greatly assisted that this paper has been prepared, and this I shall presently proceed to do. But in order to show the intimate bearing of this subject upon the iron and steel industries, it may be remarked that the manufacture of iron and steel is constantly becoming more scientific in its character; and looking at the tendency of things just now, as shown by subjects introduced at this and other meetings of the Iron and Steel

[1] A paper read at the recent meeting of the Iron and Steel Institute, by Mr. J. Jones, of Middlesborough.

Institute, there will be a rapidly increasing demand, not merely for accomplished scientific men to direct operations, but also for a highly intelligent class of workmen to carry out the practical details. Unless such workmen are available, the introduction of new processes or appliances is attended with the greatest difficulties, and doubtless owing to this cause many really valuable inventions have been abandoned. It would, however, in my opinion, be useless to attempt to overcome this obstacle to progress by any special means; it is rather to a general spread of higher education that we must look as the agency that will be most effective in raising the workmen to the requisite standard, so that they may be able to second and carry out the instructions of the directing minds. I fully believe that had a suitable class of men been procurable, the results that would have been obtained in connection with mechanical puddling would have been much more satisfactory. I think it is quite unnecessary to say more on this point. I believe it will be generally admitted that it is as desirable to have educated and intelligent workmen in the principal departments of the iron and steel manufacture as it is in any of our national industries. It is, therefore, most important that every possible means should be adopted for supplementing and extending the existing arrangements for imparting what we term "technical" knowledge; and it so happens that there is one way in which I venture to think substantial aid might be rendered in this respect. It will be remembered that when the International Exhibition of 1851 was being organized, the principal towns in the country were asked to guarantee considerable sums in case the Exhibition should not be a financial success. This appeal was heartily responded to, though, fortunately, it was not necessary to fall back upon this resource; on the contrary, the Commissioners found themselves in possession of a surplus of about £186,000 when the affair was over. This money they judiciously invested in the purchase of the Kensington Gore estate, which proved an exceedingly profitable speculation. It is estimated that if the Commissioners' income from ground rents were capitalized, and the land still available for building purposes sold, a sum would be realized representing several times the original purchase-money. An announcement has recently been made to the effect that the Commissioners propose to expend £100,000 in providing a scientific library at South Kensington, and in creating scholarships in connection with the Science and Art Department. Now, if this plan is adopted, the benefits will be almost totally confined to London, where great facilities already exist for obtaining free access to any book in the language, and the creation of a limited number of scholarships would not have much influence in promoting technical education generally. But it does not seem just and equitable to concentrate the contemplated expenditure in London. The fund out of which the requisite money is to come belongs to the country, and should be, if possible, applied in such a manner as to render it useful over an extended area. The property held by the Commissioners should in equity be dealt with in some degree with reference to the guarantees that were given by the leading towns in order to render the exhibition safe, and which were absolutely requisite before the matter could be undertaken. This view has already been strongly advocated by several provincial newspapers representing populous industrial centres, and I would strongly urge that the influence of the Iron and Steel Institute may be brought to bear, in order to obtain a general, as distinguished from a metropolitan, application of the fund now under consideration. I would not suggest that any attempt should be made to apply it in anything like strict proportion to the amounts originally guaranteed by various towns. I maintain that the Commissioners would be carrying out the spirit in which a fund of this nature should be administered if they were to render assistance within certain limits to the science colleges and institutions of a similar character that have been established in the principal manufacturing and industrial districts, and by offering aid to new institutions a great impetus would be given to the foundation of other colleges in suitable localities. If the Commissioners could be induced to capitalize their property, and to employ it in the manner indicated, the beneficial results would be vastly increased, but with the £100,000 which they now propose to spend most valuable aid might be rendered where it is most urgently needed. Nor would this plan involve the abandonment of the proposal to establish science scholarships, only these would be best localized and made tenable at the provincial colleges and institutions. But the question arises, In what form should this aid be given to the local science colleges? It would evidently be injudicious to make a grant in money to go towards building or furnishing funds. The assistance should rather be in the form of a loan, so that the property could revert to the Commissioners in case any particular institution ceased to exist or to fulfil the conditions under which the assistance was first given. For instance, to take the newly-established science college in Leeds, there can be no doubt that the loan of a library of scientific books, representing, say, £10,000, would be a most valuable aid, and would tend very much to draw students and to render the lectures of the professors more effective. The institution of a few scholarships would also be of great service, and in this manner local interest would be stimulated. Should the college at any future time cease to exist, the library would simply revert to the Commissioners, and they could make it available elsewhere. This is not the place to attempt a discussion of details; I can only indicate the principle which I consider might be most advantageously adopted. Nor is it necessary that I should specially refer to suitable institutions that already exist, and which fall at once within the category that ought to be entitled to participate in the benefits which might arise from the provincial application of the Commissioners' funds. It is sufficient to say that such institutions are already established in connection with the principal iron manufacturing districts, and, doubtless, where nothing of the kind has yet been provided, the want would be speedily supplied.

[A resolution approving Mr. Jones's suggestions, and instructing communication to be made with the Royal Commissioners for the Exhibition of 1851, was subsequently passed.]

ALCOHOLOMETER:

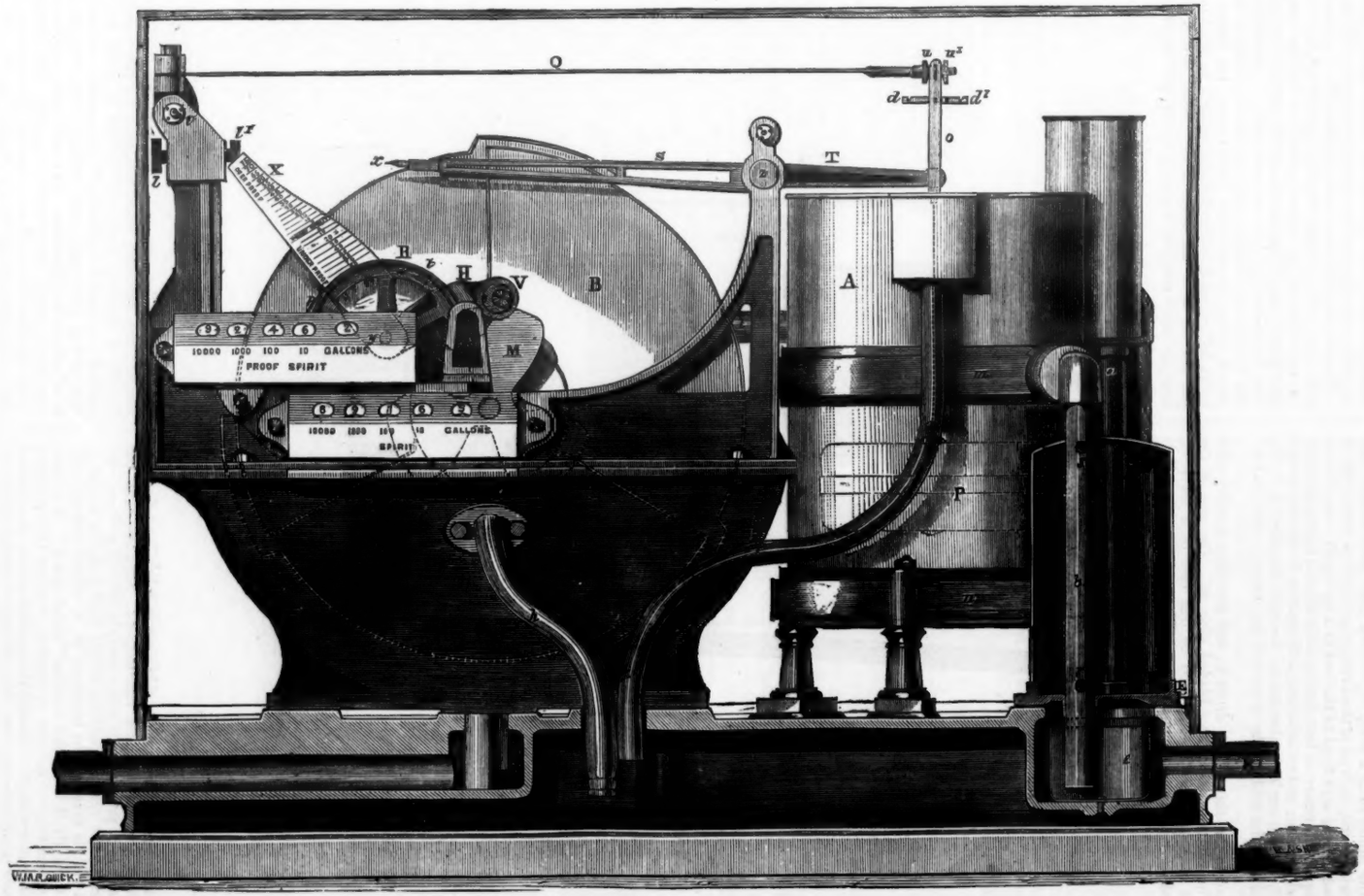
For Measuring the Quantity of Proof Spirit for Excise Duty in Distilleries.

THE instrument here described is that which has for some time been adopted by the Custom House authorities in Russia in connection with the duties on alcohol, and is likely before long to be recognized in the same way by the Governments of Germany and Denmark.

It fulfils a double purpose: it measures and registers not only the quantity of spirit which flows through it, but also the amount of alcohol contained in that spirit.

The first of these two operations is performed as follows:—The liquid to be measured, coming from the still and cooler, flows by pipe R^1, fig. 1, into a system of mixing tubes, through the vessel A, and by another pipe *l*, enters a cylindrical space D, fig. 2, inside a thin copper-plate drum B, turning on a horizontal axis. The drum B is divided into three equal compartments formed by radial partitions, and each of known volume. The three compartments are connected with D by means of three narrow slits running parallel to the axis, and with the outside by three similar slits, through which the compartments discharge their contents. Three pipes serve to lead the air away from the spaces of the compartments to be filled, and as they are always above the level of the liquid in D the liquid cannot pass through them. The liquid can flow into only one compartment at a time, and that always the one lowest down. As soon as this compartment is filled the liquid commences to rise in D, and then to flow into the compartment next in order. The centre of gravity of the system of compartments now undergoes a gradual change, causing a corresponding rotation of the drum. The compartment just filled is made to assume a higher position as the other compartment becomes more and more filled, until it is enabled to discharge its contents into a trough by means of one of the slits above mentioned. As liquid flows in, each compartment is in its turn filled and discharged. The axis of the drum gears into an indicator, and as each discharge of a compartment is accompanied with a corresponding rotation of the drum the indicator is made to advance at a corresponding pace, and the quantity of liquid which has flowed through may be read off directly from the indicator.

The amount of alcohol contained in the liquid is measured as follows:—The liquid just passing the apparatus may be of different densities, and as erroneous results would be given if the strength were to be measured when in this state, it is necessary to mix it thoroughly so as to make it of more uniform density. To effect this the liquid, as it comes from the still, flows through pipe R^1, fig. 1, into the vessel E; the denser portion of the liquid sinks into a vessel *e*, placed within E, and is forced up the pipe *b*, and by a perforated ring into the large vessel A, while the lighter liquid rises in the pipe *a*, and, by the course the pipe takes, enters A by another perforated ring low down—that is, the denser liquid is made to enter high up, while the less dense is made to enter low down. They tend to settle in the order of their densities, and in so doing have to pass through one another, thus getting thoroughly mixed, and made to have a uniform density.



ALCOHOLOMETER.

Fig. 1.

In the liquid in A a body, P, of very thin sheet copper, and filled with spirit, such as is the average production of the still, is suspended by a wire fixed to the end of a spring Q. As P floats in a liquid of greater or less density so it takes a higher or lower vertical position; and as this change of position is communicated directly to a lever T S attached to the wire suspending P, the pointer *x* at the end of the lever will be directly affected likewise.

Fixed to the axis of the drum B, and therefore turning with it in its rotation, is a three-bladed disc M. On one of the blades rests a roller V, attached to one end of a lever H, pivoted at *y*. As soon as a compartment of the drum B is filled, this lever falls between two of the blades, but is raised up again by the next blade in the course of its rotation.

Turning on the same pivot as lever H is a wheel R, gearing into a second indicator marked "proof spirit." This wheel is carried forward by a pawl acted on by the lever H, in the direction shown by the arrow, all motion in the opposite direction being checked by a counter-pawl. If the fall of H between the blades was limited only by contact against the blades, R would always rotate to the same extent; but before H descends to its full extent it is checked by an arm X, fixed to it, meeting the pointer *x* of the lever T S. This arm X is graduated into divisions ranging from 75 over-proof to 100 under-proof.

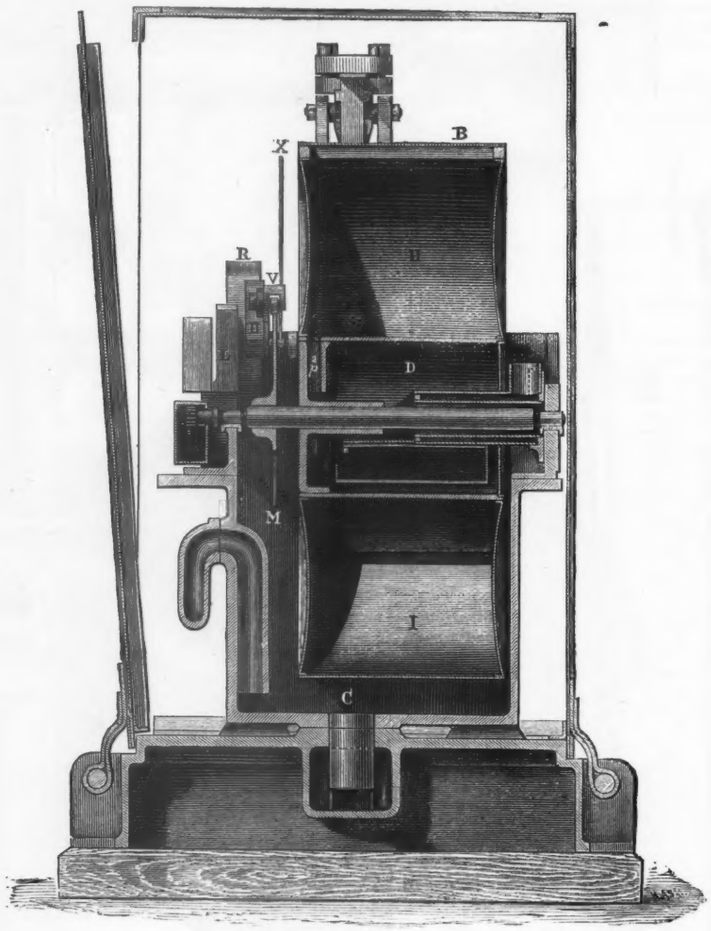


Fig. 2.

Its peculiar curved form on the side next to *x* has been fixed by a series of experiments and calculations. Suppose that the spirit in A is at proof, *x* will take a certain vertical position, determined by the vertical position of the float P in the liquid in A. As H falls between the blades of M, X moves forward and meets *x* exactly at the point marked "proof spirit." R rotates only a corresponding number of degrees, causing the indicator to advance accordingly. Should the operation take place when spirit over proof is in A, then *x* should meet X at the point corresponding to the strength of the spirit in A. But as the arm X will be longer in meeting *x*, owing to the changed vertical position of the latter, the wheel R will rotate for a correspondingly longer period, and the indicator will be advanced accordingly. Should the spirit in A be under proof, the rotation of R will be correspondingly small, and the indicator will advance to a correspondingly small amount. The proof spirit indicator thus shows the percentage amount of proof spirit, while the indication on X is the actual strength of the liquid in A. To check the accuracy of the movements of the pointer *x*, weights are supplied, corresponding to the weight of P in liquids of different densities. If one of these weights is suspended at *d* and *d*^{1} in place of P, the pointer *x* should meet X at the point of the scale corresponding to the strength of the liquid to which the weight refers. Any inaccuracy may be corrected by adjusting screws *l* and *l*^{1} before actually using the apparatus.

As the float P is of very thin metal, and completely filled with spirit, the relative densities of the liquid in the float and of that surrounding the float, and consequently the position of the float, are not affected by a change of temperature.

Besides the extensive employment of the apparatus in Russia, where several thousands are at work, other Governments, such as the German, Austrian, Danish, &c., have subjected it to searching and complete experiments, and the results have in all cases been most satisfactory, showing that the measurements made by this apparatus are more accurate than those made in the usual way by purely manual measurements. It therefore is

a most suitable apparatus for the levying of the alcohol duty in distilleries, as well as for the distiller's private measurements.

One of these apparatus is at present exhibited in the Loan Exhibition at South Kensington and another in the offices of Messrs. Siemens Brothers, 12, Queen Anne's Gate, Westminster, where it may be seen in working order, and full particulars of its construction obtained.

WOOL DYEING.

A Course of Lectures: by George Jarmain.

Lecture I.

(*Continued from page* 296.)

Purification and Correction of Waters which are to be used in the Treatment of Wool.

THE treatment of water, which is required in such large quantities, for the scouring and dyeing of wool and woollen cloths is always troublesome, costly, and unsatisfactory at the best; and it is advisable to avoid all such treatment, when possible, by obtaining the water from another source, or even by removing to new premises where suitable water is obtainable.

In case, however, no such course is practicable, the following processes may be employed, in order that the evil effects of unsuitable water may be mitigated:—

1.—Exposure to Air, Subsidence, and Filtration.

When the impurities consist of matters in suspension or of bicarbonate of iron, exposure to air in a shallow reservoir and subsequent filtration through a bed of sand will generally be found sufficient. The iron will be oxidised and rendered insoluble, and is then capable of removal by filtration. I have seen its removal effected satisfactorily by passing the water through a bed of shoddy, which acts as a very good filter.

2.—Treatment with Lime and Subsidence (Clark's Softening Process).

This treatment is only applicable to water that contains chalk, carbonate of magnesia, or iron salts in solution. The lime combines with the carbonic acid, which holds the carbonates of lime and magnesia in solution, which are thus rendered insoluble, and precipitate along with the lime added. This mode of treatment is theoretically very perfect, but there are practical difficulties in the way of treating large masses of water which render it very difficult to manage. If too little or too much lime be added the water is often made worse, and the point at which sufficient lime has been added is not very easy to determine. If a day's consumption can be treated at one time the proper quantity of lime to use can be determined by treating separate small quantities of the water with known but varying weights of lime, and after allowing it to subside over night that proportion which has softened the water most can be determined by the soap test. The quantity of water for a day's consumption should be treated with the calculated weight of lime, which should be mixed with water, and run into the reservoir, and the whole must then be agitated. This should be done at the close of the day; the carbonates will have subsided before morning. Water thus treated is very bright and clear, and if managed successfully will be found to be moderately well adapted for the treatment of wool.

3.—Treatment with a Ferric Salt, and then with Carbonate of Soda.

This method is well adapted for the removal of soluble organic impurities and suspended fine clay. It has been applied by Dr. Gunning with great success to the turbid waters of the River Meuse. For the treatment of 3,000 gallons, 1 lb. dry perchloride of iron is dissolved in water and then thoroughly mixed with the bulk; 1 lb. of soda ash of 52 per cent. is then dissolved, run in, and the whole again agitated. The hydrated peroxide of iron deposits, carrying down with it the organic impurities, common salt being the only substance left in solution.

4.—Treatment of Permanently Hard Waters (Wanklyn's Method).

As has already been explained, these waters contain the sulphates of lime and magnesia, which have always proved to be the most difficult of removal. Mr. Wanklyn has recently proposed to soften waters of this class by first adding bicarbonate of soda and then lime. The bicarbonate of soda first converts the sulphate of lime into bicarbonate of lime, and the subsequent addition of lime precipitates the bicarbonate so formed. Sulphate of soda remains in solution in the water.

I have not had an opportunity of seeing this process tried on a large scale, but I consider it likely to accomplish the end in view, if its cost should not prove to be a bar to its use.

5.—Treatment of Hard Waters with Soap.

If hard water must of necessity be employed for scouring with soap, it is advisable to separate the hardening matter by mixing a sufficient quantity of a hot solution of soap with it, and then causing it to run through a filter-bed before use. The insoluble soaps will thus be separated without attaching themselves to the wool or fabric, and they may be collected and treated with hydrochloric acid, to decompose them and separate the fatty acids, which may then be collected and reconverted into soap by boiling them up with caustic, or even carbonate of soda, and the soap thus obtained may be used again for the same purpose. Water thus treated is well adapted for the scouring of wool and woollen goods.

6.—Treatment and Correction of Waters in the Dye-bath.

Organic matter, oxide of iron, and often a considerable proportion of the hardening matter, may be caused to rise to the top, and may then be skimmed off, by dissolving alum in the water in the proportion of about 4 oz. per 1,000 gallons, and then raising it to near its boiling point.

In preparing waters which contain alkaline or earthy carbonates or bicarbonates as a bath for either mordanting or dyeing, they should be treated with sufficient sulphuric acid to expel all the carbonic acid, and to neutralize any alkali which may have escaped washing out from the scour.

The use of bran is frequently serviceable in removing impurities from water in the bath.

Purification of the Refuse Waters from Woollen Mills.

In concluding my remarks on the subject of water, I beg to draw attention to the fact that the refuse waters from a woollen manufactory contain within themselves the elements of their own purification. At the present time the practice is to turn these refuse waters into the river-courses as they are done with. Sometimes mordant-baths are run out, at other times the spent dye-baths, and soap, or alkaline fluids. These mingle in the common receptacle, the river, and precipitate each other there, thus producing those black deposits which give to our streams in the woollen districts such an inky and foul appearance. I have mixed together solutions of all the substances used in our woollen industries, and find that they precipitate one another, and leave the supernatant water in a tolerably clear condition. The remedy seems to be, so far as the woollen trade affects the purity of the rivers, to run all the liquids into one common reservoir, and, after subsidence, to pass, if necessary, the supernatant water through a filter-bed into the river. The utilization of the black muddy deposit would, I believe, speedily follow.

Scouring.

I have now to draw your attention to the cleansing of wool and woollen fabric, in preparation for its subsequent treatment in the dye-house.

Raw wools always contain a considerable amount of organic and earthy impurities. The most abundant of these is suint, a peculiar organic body containing potash. M. Chevreul gives the following as the composition of merino wool:—

Earthy matter	26·06
Suint	32·74
Greasy matter	8·57
Earthy matter fixed by the grease .	1·40
Clean wool	31·23
	100·00

I am not aware that any attempt has been made in England to utilize the wool impurities. A very pure potash salt is, however, manufactured from them in France.

Scouring Materials.

The following are the detergents in use in the woollen industry:—Urine, ammonia, soda ash, soda crystals, soap (hard and soft), silicate of soda, and various compositions containing carbonate of soda.

Many manufacturers prefer to use stale urine, which contains a considerable quantity of carbonate of ammonia, a particularly

mild alkali. The organic matter in the urine appears also to assist in cleansing, and it protects the woollen fibre from injurious action by alkalies.

Ammonia is also a mild alkali, and, for the treatment of wool, that distilled from urine is preferred to all other kinds. The strength of ammonia is determined by taking its specific gravity by means of a hydrometer, called an ammoniameter. The one in common use in Yorkshire and Lancashire has an arbitrary scale, each degree equalling 3, water being taken at 1·000. Thus, the specific gravity of ammonia at 20° equals 1·000 — (20 × 3) = ·940. The crude ammonia distilled directly from gas liquor frequently contains hydrocarbons and sulphide of ammonium. The former can easily be recognized by pouring some of the ammonia on a plate; after a few hours, when the ammonia has passed away, the tarry smell of the hydrocarbons will be perceptible. Sulphide of ammonium is readily distinguished by the dark colour which the ammonia gives when treated with a solution of acetate of lead, or by the blackening of a silver coin when dipped into it, the black sulphides of lead and silver being formed respectively.

The hydrocarbons act strongly on the skin of the workman, and the sulphides act injuriously on the wool.

Carbonate of soda is the most extensively used scouring agent; it enters largely into the composition of many detergents bearing fancy names. The following are the principal forms in which it is employed in the woollen manufactory:—Soda ash, containing from 30 to 52 per cent. available alkali; (oxide of sodium) soda crystals, containing 21·7 per cent. available alkali; soap ash, containing 21·7 per cent. available alkali and a small quantity of soap or palm oil; dry soap (good), containing $\frac{2}{3}$ carbonate of soda and $\frac{1}{3}$ soap; urine substitute, melted soda crystals.

The value of these substances as detergents is in proportion to the available alkali (oxide of sodium combined as carbonate) which they contain. Dry soap, however, contains in addition a considerable quantity of soap.

I have occasionally seen the workman gauging the strength of his soda ash liquors by means of a hydrometer; this is a foolish plan, because the salt and other impurities contained in weak soda ash add to the density of its solution and give to it a fictitious strength.

It is important that the foreman should know what is the available strength of the soda ash he employs. I have found the following plan to give sufficiently accurate results in the hands of an intelligent workman:—

Apparatus required.—One burette, 50 cubic centimetres in $\frac{1}{5}$; one holder for ditto; one 100 cubic centimetres graduated measure; one litre measure; one box scales and weights to weigh to $\frac{1}{10}$ of a grain; one boiling flask; one filtering funnel and filter paper; one spirit lamp, or Bunsen burner where gas is in use; one retort or tripod stand, and a piece of wire gauze; infusion of litmus; one $\frac{1}{2}$-oz. porcelain crucible; one 4-oz. beaker glass. Most of these are included in the soap test apparatus.

Two standard solutions are required, viz., standard sulphuric acid, and a solution of caustic soda which exactly neutralizes an equal volume of the standard sulphuric acid.

The acid is made of such a strength that 1 cubic centimetre of it neutralizes $\frac{1}{2}$ grain of oxide of sodium (soda).

The preparation is as follows:—About 200 grains of pure carbonate of soda, or, failing that, Howard's bicarbonate, are heated to redness for an hour in the porcelain crucible over the lamp, to expel moisture, &c. When cold, weigh out carefully 171 grains of it, dissolve it in a little distilled water in the beaker, pour it into the 100 cubic centimetres measure, rinsings as well, and make up to 100 cubic centimetres with distilled water; pour into a bottle and add to it another 100 cubic centimetres of distilled water.

Every cubic centimetre of this solution contains $\frac{1}{4}$ grain of oxide of sodium, and is used to prepare an acid solution of equal strength—the standard sulphuric acid.

The acid is prepared in the following manner:—About half fill the litre measure with distilled water, pour into it 31 cubic centimetres of strong sulphuric acid, D. O. V. 170° Tw., fill up to the litre mark with distilled water, then pour into a bottle to mix it. This acid will be too strong, and will require an additional quantity of water; its actual strength, as compared with the prepared solution of carbonate of soda, must now be ascertained. Pour 100 cubic centimetres of the standard carbonate of soda solution into the boiling flask, add another 100 cubic centimetres of distilled water and a few drops of the litmus; fill the burette up to the top mark with the diluted sulphuric acid, and run it into the flask until the litmus begins to redden; then boil to expel carbonic acid; run in more of the sulphuric acid in repeated small quantities until the blue colour begins to permanently redden, boiling after each addition. When the exact point has been reached, read off the number of cubic centimetres which have been used; if, say, 94 cubic centimetres of the diluted acid have been used, then the acid of the proper strength will be made by adding 6 of water to 94 of the trial acid; in order that this mixture may be made, pour 60 cubic centimetres of distilled water into the litre measure, fill up to the mark with the trial acid, and mix as before by pouring it into a bottle. This is the standard sulphuric acid, every cubic centimetre of which neutralizes half a grain of oxide of sodium, and which alone will enable the workman to test his soda ash and other materials depending for their value upon the available oxide of sodium they contain.

The process is as follows:—Weigh out 50 grains of the ash, put it into the flask with 100 cubic centimetres of distilled water, and heat until dissolved; filter; if any portion remains undissolved, wash the filter, add a few drops of litmus liquid, run in the standard sulphuric acid from the burette, and find the neutral point as before, boiling between each addition of acid until the litmus shows signs of reddening. Read off the acid taken; the number of cubic centimetres of acid required is the percentage of available alkali contained in the soda ash examined, no calculation being required; for each cubic centimetre of the acid neutralizes half a grain of oxide of sodium, and 50 grains were taken.

The operation may be shortened, and made more exact, by using a second standard solution, viz., one of caustic soda, which contains half a grain of oxide of sodium per cubic centimetre. This solution is prepared by testing with the standard acid a solution of caustic soda made a little too strong, and then diluting it to standard strength in the same manner as was done with the sulphuric acid.

To test a sample with the two solutions, weigh out 50 grains, and dissolve, with the precautions given above; measure into it an excess of standard acid, say 60 cubic centimetres, if a strong soda ash be under examination; boil until all carbonic acid is expelled, add a few drops of litmus, which will redden if the proper amount of acid has been added, then neutralize the excess of acid by running into it from the burette the standard solution of caustic soda until the red colour begins to change to blue. The number of cubic centimetres of caustic soda required to do this is a measure of the excess of acid used; the percentage of available alkali is, therefore, ascertained by deducting the cubic centimetres of caustic soda from the cubic centimetres of standard acid used; the remainder represents the available alkali.

The following is an example:—50 grains of soda ash were dissolved in hot water and filtered into a flask, and 60 cubic centimetres of standard acid were added, and the whole boiled for ten minutes. Litmus was then added, and it was found that it required 8 cubic centimetres of standard caustic soda before the blue colour of the litmus was restored. The percentage of available alkali was, therefore, 60 — 8 = 52 per cent.

The process given above determines the true percentage of available alkali, and does not take account of the absurd standards which trade customs sanction in Liverpool and Newcastle.

The advantages derived from being able to ascertain the amount of alkali in a detergent are:—

1. The manufacturer knows when he gets his money's value.
2. The workman knows when he is using the right quantity of materials.

Soap.—Soap consists of a fatty acid in combination with potash or soda, water, and impurities of no detergent value, or positively injurious. The value of a soap depends upon the amount and correct proportions of fatty acid and alkali. The former is determined by weighing out 50 grains of the soap, and boiling it in a beaker glass in distilled water till dissolved, adding 10 grains of solid paraffin, and then about 10 cubic centimetres of sulphuric acid, diluted in a little water; the whole is then boiled gently until the liquid clears, and the oily matter completely rises; it is then set aside till quite cold, when the fatty acid can be removed in a cake, dried upon blotting-paper, and weighed. The weight, from which the paraffin added must be deducted, gives the fatty acid, the double of which, if 50 grains have been taken, is the percentage.

The percentage of soda can be obtained in the same manner as is used for soda ash. In soft soaps, which contain potash instead of soda, the potash (oxide of potassium) is obtained by multiplying what is obtained by the soda process by 1·516, or roughly calculating for potash half as much more as the soda indication. The equivalent of potash is 94 and that of soda is 62.

Silicate of Soda.—This material is coming into favour as a detergent; it cleanses wool very satisfactorily, and leaves it in a suitable condition for the reception of dyes, particularly those of the aniline colours.

Wool Scouring.

The detergents used are, soft soap for fine long wools; and for short wools, both coarse and fine, urine alone, or urine and soda

ash, or soda ash alone, silicate of soda, and various mixtures of alkaline carbonates and soaps.

The best temperature for the scouring of loose wool is from 125° to 135° Fahr.

The old-fashioned mode of scouring wool, and which gives fair results, is to work it about in a kettle or tub containing the scouring liquid with a stick or stang for five or ten minutes, and then lift it out upon a scray with the stang or a fork, by small portions at a time. When it has drained upon the scray it is thrown into a cistern called a "wash-off," the bottom of which is fitted with perforated iron plates. Water is then run into the cistern by a five or six inch pipe entering horizontally, and when full the wool is stirred up well in it. The water is then let out from under the perforated plates by means of a clack. The washing with water is repeated two or three times. This method requires an abundant supply of water, but is in other respects economical. An improvement upon this process, very often resorted to, is, to have a perforated sheet iron shell swung on a trunnion and fixed to a crane. The shell is lowered down into the scouring pan, and the wool scoured in it; when ready, it is drawn out by the crane and the wool thrown out into the wash-off cistern by tilting the shell over. The wool is washed two or three times as before. One man can scour from 500 lbs. to 600 lbs. per day by the first mode; it requires two men to scour by the perforated shell, but more work can be got through.

For certain classes of wool, in which soap is employed as the detergent, the scoured wool is passed between rollers instead of washing it.

Long stapled wools are manipulated with forks by hand in the scouring fluid.

In most large factories, however, the above processes for cleansing wool from their natural impurities have been superseded by the introduction of wool-scouring machines, the first of which which was invented in 1851, by Mr. John Petrie, jun., of Rochdale, who has since that time very greatly improved the machine; in fact, the latest form of it, the "Paragon," as he calls it, leaves little to be desired.

A complete machine consists of three boxes or bowls. The wool is fed into the first by a boy. In this bowl a strong scour is placed, through which the wool is forked by forks ingeniously fixed to cranks; from this bowl it is passed through rollers into the second, which contains a weaker scour; it then passes through rollers to the third, in which it is forked through running water; and lastly passes between heavy squeezing rollers and is thrown forward by a powerful fan, which leaves it light and open. The wool is turned out very clean and half dry. In fact the machines perform a large amount of work in a very satisfactory manner, and the manufacturers who use them tell me that they are very much pleased with them. McNaught's and Leech's machines, each possessing special features of its own, are also spoken well of by those who use them.

Yarn Scouring.

The impurities to be removed by scouring from woollen yarns are, oil, which has been used to enable the wool to be scribbled and spun, and accumulated dirt. The detergent used is a mixture of soap and ammonia, but for some descriptions of yarns cheaper alkaline liquids may be used.

It is important that the felting of the yarn should be avoided as much as possible. This may be accomplished by steeping the yarn in hot water and leaving it to cool before scouring.

The scouring is done in a wood cistern filled with the scouring fluid; the yarn is hung on sticks placed across the cistern, it is turned over frequently, and worked about in the scour, and finally wrung out. The best temperature for the yarn scour is from 140° to 150° Fahr.

Cloth Scouring.

This is always done in a machine consisting of a bowl or cistern, and squeezing rollers placed above. The scouring materials vary with the description of cloth—soda ash, soda crystals, and soap ash being usually employed for woollen cloths. The cloth passes through the scouring liquid heated to from 150° to 160° Fahr., and then between the rollers for some time, whereby the oil contained in the cloth is removed in the form of an emulsion by the detergent. The scour is frequently used again, after being strengthened by the addition of more alkali. The cloth is finally washed in clean running water on the machine for a considerable time. The thorough removal of all oil, soap, and grease from the cloth is very important for the subsequent dyeing, for if any remain in it the action of the mordant is seriously interfered with.

Wool Bleaching.

The mode of bleaching woollen goods in general use at the present day is of a very primitive character, there having been but little improvement in the process since the days of Pompeii, in the ruins of which, Pliny tells us, there were found traces of the art. As in those days, so now, a closed chamber, in which the goods to be bleached are hung up, is filled with the fumes of burning sulphur, and the goods left exposed to the action of these sulphurous fumes for some hours, during which time the yellow colouring matter of the wool is more or less affected, probably by the reducing action of the sulphurous acid, whereby the colouring matter is transformed into a colourless substance. The bleaching, however, is not of a very permanent character, the colour being liable to return, especially if the goods are treated with alkaline solutions, which frequently favour oxidation. The bleaching of wool with sulphurous acid is, therefore, not so satisfactory as the bleaching of cotton with chlorine.

Chlorine is not suitable for the bleaching of wool, for it attacks and damages the fibre without bleaching it. Sulphurous acid is the only bleaching agent which has proved effective for wool. The operation is called "sulphuring," or "stoving." The sulphur stove is built of brick or stone, and often lined with wood, as few nails as possible being used, to prevent damage from sulphate of iron, which is formed by the sulphurous acid, combined with air, acting upon the nails. The goods to be bleached are well soaped and washed, and while in a moist condition are hung up in the room. A quantity of sulphur is placed in an iron dish in the room, and a red-hot piece of iron is dropped among it; the door is then closed, and the room left undisturbed for some hours. The door is then thrown open, and the sulphurous acid gas escapes; the goods are then removed, and washed, to free them from the sulphurous acid, which, if left in contact with the fibre, would become sulphuric acid by the oxidising action of the air.

Certain improvements have been suggested in the management of these sulphur chambers, having for their objects economy in the use of sulphur; the more equal diffusion of sulphurous acid in the chamber, and, consequently, more regularity in its action; and, lastly, prevention of the destructive action on vegetation arising from the escape of the sulphurous acid on opening the door. In the "Moniteur de la Teinture" for 1872 an arrangement is described which is likely to accomplish this object. Sulphurous acid, produced in a sulphur burner, is forced into the chamber by means of a small steam jet, and when the goods have been exposed in the room for the proper time the sulphurous acid is drawn out by an aspirator and is absorbed by carbonate of soda, which it converts into sulphate of soda. An additional improvement consists of an arrangement for passing the goods through the chamber by means of rollers. The bleaching of cloth can thus be made continuous.

Lecture II.

One or two processes stand over from the last lecture for consideration now.

During the last few years a solution of sulphurous acid has been employed, to a considerable extent, for the bleaching of wool. Liquid bleaching presents many advantages over gas bleaching for loose wool, which is much more easily manipulated in a liquid than it can be in the sulphur chamber. On the other hand, sulphurous acid in solution is not as effective a bleacher as it is when in the gaseous state, and the solutions are troublesome to make, or more expensive to purchase than the sulphur, which is the only article required in the gas-bleaching process.

The solution of sulphurous acid used for bleaching purposes is one of the following:—

1. A solution of the gas in water.
2. A solution containing from 3 to 5 per cent. of bisulphite of soda, to which an equal volume of hydrochloric acid is added.
3. A solution, containing from 3 to 5 per cent. of the bisulphite, from which the sulphurous acid is set free in a subsequent operation.

The wool to be bleached should be well scoured with soap, washed, and steeped in one of the above solutions for some hours. If the first or second solution be employed, it will only require to be washed to free it from the acid; it may then be placed in a coach, and covered up with a sheet for some time, under which circumstances the bleaching action will be continued by the sulphurous acid remaining adhering to the wool.

If the third solution be employed, the wool, after draining, should be passed into water containing from 3 to 5 per cent. of hydrochloric acid, which will liberate the sulphurous acid from the bisulphite of soda with which the wool is soaked, and the sulphurous acid being liberated in contact with the fibre, and probably within the fibre itself, the colouring matter of the wool is acted upon more powerfully by this nascent condition of the bleaching agent than it is by free sulphurous acid. This method resembles the bleaching of cotton by bleaching powder in the liberation of the bleaching agent by an acid.

Solutions Nos. 1 and 2 rapidly lose strength by the escape of the sulphurous acid, or by its conversion into sulphuric acid by

oxidation. Some loss is, therefore, experienced when the bleaching is only required to be done occasionally. The sulphurous acid may be preserved in them to a considerable extent by neutralizing it with carbonate of soda; when required again, it can be set free by the addition of hydrochloric acid. No. 3 solution holds its strength much longer than Nos. 1 and 2; and, although it requires a little more labour, the bleaching by it is more effective.

The following equation explains the action of the hydrochloric acid upon the bisulphite:—

$$\underset{\text{Bisulphite of soda.}}{H\,Na\,SO_3} + \underset{\text{Hydrochloric acid.}}{HCl} = \underset{\text{Common salt.}}{Na\,Cl} + \underset{\text{Sulphurous acid.}}{H_2SO_3}$$

The colour of the wool is often improved by tinting it with a little blue; this may be done in the acid bleaching bath, or, better still, in a bath specially made up for the purpose after the bleaching has been done. I have found a solution of indigo carmine to be best adapted for the tinting; but where the wool is very yellow, it is necessary to use a red colour in addition. The colour may be given in the cold.

Bisulphite of soda solution of 45° Tw. is sold at the present time at 9*s.* per cwt.

When required in large quantities for bleaching purposes, or for the preparation of reduced indigo by Schutzenberger and Lalande's method, it may be made by absorbing in a solution of carbonate of soda the sulphurous acid gas produced by burning sulphur. The absorption may be made in a coffee still, or in a tower made of sanitary pipes filled with coke; or, finally, the gas may be absorbed by aspirating it, or by forcing it through the alkaline solution. The gas should be passed till after all effervescence has ceased, and until it is no longer absorbed.

The solution of bisulphite may also be prepared, if required in smaller quantities, by heating crushed charcoal soaked in strong sulphuric acid in an iron vessel, and conducting the gases evolved into a solution of carbonate of soda till saturated. And for small experimental purposes it may be made by heating in a flask strong sulphuric acid, to which is added either copper turnings or crushed charcoal, and conducting the sulphurous acid gas produced into a bottle containing solution of carbonate of soda, and shaking it up from time to time until no more gas is absorbed.

The following equations explain the reactions involved in the above operations:—

$$\underset{\text{Sulphurous acid gas.}}{2\,SO_2} + \underset{\text{Water.}}{OH_2} + \underset{\text{Carbonate of soda.}}{Na_2CO_3} = \underset{\text{Bisulphite of soda.}}{2\,HNaSO_3} + \underset{\text{Carbonic acid gas.}}{CO_2}$$

$$\underset{\text{Sulphuric acid.}}{2\,H_2SO_4} + \underset{\text{Charcoal.}}{C} = \underset{\text{Sulphurous acid gas.}}{2\,SO_2} + \underset{\text{Carbonic acid gas.}}{CO_2} + \underset{\text{Water.}}{2\,OH_2}$$

$$\underset{\text{Sulphuric acid.}}{2\,H_2SO_4} + \underset{\text{Copper.}}{Cu} = \underset{\text{Cupric Sulphate.}}{CuSO_4} + \underset{\text{Sulphurous acid gas.}}{SO_2} + \underset{\text{Water.}}{2\,OH_2}$$

Tinting or Dyeing White.

There are some descriptions of wool and woollen waste, the yellow colour of which is but little affected by the action of sulphurous acid, but which may be very greatly improved in tone by tinting with the complementary colours, blue and red. The wool, waste, or cloth is well scoured in soap; the tinting bath is made by heating up water to about 120°, and adding the tinting colours. Good proportions and colours for 250 lbs. yellow material I find to be—three tablespoonsful of Brook, Simpson, and Spiller's Humboldt; two tablespoonsful of Brook, Simpson, and Spiller's No. 1 B blue. Work in the bath for forty minutes.

For some descriptions of goods other colours and proportions may be found to be better adapted; the above directions are merely intended to indicate the course to be adopted.

INDIGO.

The importance of this colouring agent in the woollen trade cannot be over-estimated. Our finest and most expensive cloths are dyed with it, often with it alone, and frequently it forms the base upon which other colours are dyed.

Indigo has been known and used as a dye from the earliest times of cloth manufacture. It was employed by the Egyptians at a very early period, for it is found on mummy cloths; and the ancient Hindoos, Chinese, Greeks, and Romans were known to use it.

Indigo is a product of the vegetable kingdom, and is sometimes found in small quantities in animal secretions. Many attempts have been made to produce it artificially for industrial purposes, but as yet without result. The success which has attended the preparation of artificial alizarine, however, encourages the hope that at no distant day the production of artificial indigo for the use of the dyer will be added to the triumphs achieved by chemists in the production of tinctorial substances.

The plants from which indigo is derived belong chiefly to the family Leguminosæ, and genus Indigofera. The species most cultivated and esteemed are—*I. tinctoria*, *I. disperma*, *I. anil*, *I. argentea*. The production of indigo is not confined to the Indigofera, for it is furnished also by the woad plant, *Isatis tinctoria*, belonging to the Compositæ family, and by other plants.

Indigo does not appear to exist in the plant in either of its well-known conditions, but is a product of a species of fermentation, to which the leaves are subjected during its preparation, the details of which I will not enter upon.

Asiatic indigoes are produced in Bengal, Oude, Coromandel, Manilla, Madras, and Java.

African, in Egypt, Mauritius, and Senegal.

American, in Guatemala, Caraccas, Mexico, Brazil, and Carolina.

The Bengal, Java, and Guatemala varieties are most esteemed. The Java is preferred for the manufacture of indigo carmine on account of its purity of colour. Its percentage of colouring matter is not very high, and the woollen dyer consequently prefers varieties richer in colour.

The best varieties of Bengal indigo have a deep blue violet colour. They are fine grained, and adhere to the tongue. They are easily pulverized, and have a coppery hue when rubbed with the nail. Sp. gr. an average of ·769. The colouring principle upon which the value of indigoes mainly depends ranges from 12 to 72 per cent.

The examination of indigo, so far as it concerns the dyer, includes:—

1. The determination of the percentage of mineral matter.
2. Its tinctorial power, compared with a standard sample of good indigo, or with indigotin, the pure colouring matter of indigo.
3. The amount of indigotin it contains as compared with a standard sample.
4. Its physical characters, such as its specific gravity, colour, ease with which it powders, appearance when rubbed with the nail, action on the tongue, fracture.

1. The mineral matter is determined by burning in a platinum capsule over a spirit lamp or Bunsen flame a known weight, say 20 grains, of the powdered indigo, until all carbonaceous matter disappears, and weighing the ash. If 20 grains have been taken five times the weight of the ash will give the percentage of mineral matter. The combustion will be complete in about an hour, but will be much facilitated by breaking the coke and stirring it up at intervals with a platinum wire. Good indigo does not leave more than 10 per cent. of ash, and the best Bengal seldom more than 7 per cent.

2. Its tinctorial power is found, as compared with the standard sample, by placing five grains of each in a 2-ounce porcelain dish, pouring on each five cubic centimetres of strong sulphuric acid, or, better still, of fuming sulphuric acid, and digesting them for an hour or two at a gentle heat. Water is then added, and they are run into the 100 cubic centimetre measure, and then emptied into a beaker or flask to mix the solution. Five cubic centimetres of the sample under examination are then taken up with a pipette and run into 100 cubic centimetres of water placed in a glass cylinder, or tall white glass bottle, and the solution of the standard sample is run into another 100 cubic centimetres of water from a graduated pipette or from the burette, until a colour is obtained equal to that of the sample under examination. The relative amounts of solution required to produce the same depth of colour give the relative tinctorial values of the indigoes. Fifty cubic centimetres of the remainder of each solution are placed in a small pan, dish, or beaker, along with 50 cubic centimetres of water, and swatches of woollen cloth of equal weight are dyed in them, the heat being raised nearly to the boil. The depth of colour obtained in each case will give the relative tinctorial values of the indigoes.

3. To obtain the amount of indigotin, as compared with a standard sample, pour 10 cubic centimetres of the solution (as obtained in 2) into a pint of water contained in a flask or beaker, and run in from the burette a solution of permanganate of potash, until the blue colour disappears and the solution becomes golden yellow. Treat 10 cubic centimetres of the standard solution in the same way. The number of cubic centimetres of permanganate required in each case gives the relative amount of pure indigotin in each sample. A convenient strength of solution of permanganate is made by dissolving five grains of the crystals in one litre of water.

Solutions of bichromate of potash or of bleaching powder may also be used for destroying the colour of the indigo solu-

tions, and the percentage of indigotin calculated from the amount of solution required in each case.

4. The examination of the physical characters of the indigo needs no comment.

Indigo, as met with in commerce, is insoluble in water, alkali, and dilute acids, and its treatment for bringing it into solution, in order that it may be used as a tinctorial agent, depends upon the fact that it is rendered soluble by the action of nascent hydrogen, whereby it is converted into white, or so-called reduced indigo, which is then soluble in alkaline fluids, such as lime, soda, or potash. This is effected by various means, according to the class of goods which are required to be dyed with it. The vessels in which the goods are to be dyed are called vats, and the substances used to reduce or hydrogenize the indigo give the name to the vat. These vats may conveniently be divided into—1, Cold vats; 2, warm vats.

The cold vats are used for dyeing cotton or other vegetable substances; warm vats are invariably used for wool and woollen goods.

The following equation will explain the conversion of insoluble blue indigo into soluble white or reduced indigo:—

$$\underset{\text{Indigo blue.}}{2\,C_8H_5NO} + H_2 = \underset{\text{Indigo white.}}{C_{16}H_{12}N_2O_2}.$$

Two molecules of the former being converted into one of the latter by the nascent hydrogen.

The following table exhibits the various materials and means employed to bring about the conversion, and the name of the vat:—

INDIGO VATS.

Copperas vat . . .	Cold .	Copperas, lime, and soda or potash.		Cotton and vegetable substances.
Woad vat	Warm .	Woad, madder, bran and lime	By fermentation 140° Fah.	Wool and woollen goods.
Pastel vat	Ditto .	Pastel, madder, bran, lime .	By fermentation, not beyond 158° Fah.	Ditto ditto.
Pastel potash vat . .	Ditto .	Pastel, madder, bran, lime, potash; and, for some classes of goods, molasses.	By fermentation 120° Fah.	Ditto ditto.
Urine vat	Ditto .	Urine, salt, madder . .	. . . . .	Useful for small dyers.
The German soda vat .	Ditto .	Bran, carbonate of soda, lime, molasses.	By fermentation 120° Fah.	Wool and woollen fabrics.
Schutzenberger and Lalande's vat.	Warm or cold.	Zinc dust, bisulphite of soda, lime.	By simple admixture .	Wool and woollen in warm vat; cotton in cold.

In the copperas vat, in which a mixture of copperas and lime is employed, the nascent hydrogen is produced as follows:—The lime precipitates ferrous hydrate (hydrate protoxide of iron) from the copperas thus:—

$$\underset{\text{Copperas.}}{FeSO_4} + \underset{\text{Slaked lime.}}{CaH_2O_2} = \underset{\text{Sulphate of lime.}}{CaSO_4} + \underset{\text{Ferrous hydrate.}}{FeH_2O_2}$$

The ferrous hydrate then takes up oxygen from water:—

$$\underset{\text{Ferrous hydrate.}}{2Fe_2H_2O_2} + \underset{\text{Water.}}{2OH_2} = \underset{\text{Ferric hydrate.}}{Fe_2H_6O_6} + \underset{\text{Nascent hydrogen.}}{H_2}$$

Soda and potash, which are sometimes used in place of lime, act in the same manner.

In the fermentation processes, the woad, pastel, bran, and madder act as the ferments, by virtue of the nitrogenous matter which they contain; the sugar of the madder and the farina of the bran pass successively into grape sugar, lactic acid, and finally into butyric acid, the production of the latter being accompanied by the evolution of hydrogen and carbonic acid, the following equation representing the change:—

$$\underset{\text{Lactic acid}}{2\,HC_3H_5O_2} = \underset{\text{Butyric.}}{HC_4H_7O_2} + \underset{\text{Carbonic acid gas.}}{2CO_2} + \underset{\text{Hydrogen.}}{2H_2}$$

The nascent hydrogen thus produced is the reducing or hydrogenizing agent.

In Schutzenberger and Lalande's vat, the hydrosulphite, formed by the zinc acting on bisulphite of soda, decomposes water, taking up oxygen from it and liberating the hydrogen, itself passing into a higher state of oxidation. These changes are at present not very well understood.

The only vats employed in England for the dyeing of wool, so far as I can learn, are the woad vat, and that of Schutzenberger and Lalande. There seems to be a strong objection amongst English dyers to the employment of soda or potash, in consequence of vats being made caustic by the use of these alkaline carbonates along with lime. Caustic potash or soda is exceedingly prejudicial to the soundness and handle of the wool, especially when it is heated along with it; and Schutzenberger and Lalande's vat was not at first well received, because soda was used as the solvent of the reduced indigo, and many complaints were made that it rendered the pieces rotten. This is, however, now avoided by the use of lime only as the solvent, too great an excess of lime being carefully avoided.

Utensils.

The indigo mill is a very important apparatus. Unless the indigo is thoroughly ground great loss of that material will take place. Indigo can only be reduced when brought into the condition of an impalpable powder. The mill is either constructed of stones, somewhat like those for grinding corn, and worked by a perpendicular shaft, or it consists of four iron rollers, which are rolled backwards and forwards in a trough by a cradle motion. The indigo is ground with water to a pulp, the operation being continued for several days. The pulp must feel perfectly smooth, and contain no gritty particles.

The vat is a cylindrical iron vessel, having a diameter and depth of 6 ft. 6 in. by 6 ft. 6 in. to 7 ft. 6 in. by 7 ft. 6 in. It is encased by an iron jacket or by brickwork, and heated by steam, the steam space in the jacket being about 2 in. wide, and extending from the bottom to within 4 ft. of the top. Sometimes the vats are heated by a coil of copper pipe placed inside the vat, which is an economical arrangement. Direct fire heat is now but seldom employed.

Rakes are used to stir up the contents of the vats. The rake-head is about 15 in. long by 5 in. wide, and the handle is 10 or 12 feet long. The rake is lowered down to the bottom of the vat, and a portion of the sediment is drawn up with a jerking motion when the head approaches the surface. Three or four men work up the vat in this manner vigorously for about ten minutes.

When not in use, the vats are covered by a cover, in three pieces, made of battened three-quarter-inch boards. This keeps in the heat, and prevents oxidation of the vat liquor to a great extent.

A net of half-inch meshes is lowered down into the vat when wool has to be dyed. The wool is gently moved about in the net by means of a "stang," care being taken that it is not lifted out of the fluid.

When the wool has been in the vat a sufficient length of time, it is lifted out of the net and placed in a bag made of strong net. The wool is then wrung in the bag, and the liquid returned to the vat.

Pieces, when placed in the vat, are moved about by means of an instrument called a "hawk," one of which is held in each hand, and the piece is pulled towards the operator. It must not be raised above the liquor. In order to prevent the piece from sinking down into the sediment at the bottom of the vat, an iron hoop of the same diameter as the vat, covered with a net having 4 or 5-in. meshes, is lowered down about a yard below the surface of the liquid, and suspended there.

A movable squeezing machine, consisting of two iron rollers 6 in. in diameter, fixed in a framework, serves the purpose of removing pieces from the vat. One or both rollers may be covered with vulcanized india-rubber.

Materials used in the Woad Vat—Woad, Madder, Bran, Lime Indigo.

Woad consists of the fermented leaves of the woad plant, *Isatis tinctoria*. This article is grown and manufactured largely in Lincolnshire. The seeds are sown in early spring, and when the plants are large enough they are transplanted in rows. When the plants are from 3 to 6 inches high, the outer leaves are twisted off by children, and then placed under a shed. Usually three crops are thus gathered during the season. The manu-

facture of the woad is carried on in the winter. The leaves are mixed with lime and urine, and thrown in a heap to ferment. The heap is repeatedly turned over with shovels to prevent excessive fermentation; this turning of the heap is continued until fermentation ceases. The woad is then packed in barrels and sent to the market. The present price of woad is from £26 to £30 per ton. (Sample exhibited.)

Madder contains sugar and nitrogenous matter in addition to its colouring matters. The sugar passes into the butyric fermentation, and furnishes part of the nascent hydrogen; the nitrogenous matter acts as a ferment. The ordinary crop madder is employed. The use of madder in the fermentation vats is not essential, and in many establishments it is not employed. The colouring matter of the madder gives a special shade to the indigo which some manufacturers like.

The bran used is the ordinary bran obtained in grinding wheat. It contains nitrogenous matters and starch; the former assist as a ferment, and the latter passes during the fermentation through the various stages of glucose, lactic acid, and butyric acid, nascent hydrogen being produced at the latter stage.

Newly burnt lime slaked and riddled is thrown into the vat in the powdering condition. Its employment serves the purpose of neutralizing the butyric acid as fast as it is formed. When the addition of lime is neglected too long, the butyric acid and other matters pass into the putrid fermentation, which acts destructively upon the indigo.

The indigoes found to be the most economical and effective for woollen dyeing are the medium qualities of Bengal, ranging, at the present time, from 4*s.* to 5*s.* per lb. The violet copper-coloured varieties, having a low specific gravity, are prepared. (Samples exhibited.)

Preliminary Operations.

When the indigo-dyed goods are required to have a special "bloom," the wool or woollen fabric has a "bottom" put on it. Camwood, barwood, Saunders'-wood, cudbear, archil, or archil paste, are the colouring matters which are employed for this purpose. Camwood is the best for wool. The woods give a much more permanent bloom than the weed colours, cudbear and archil, which are somewhat fugitive.

The goods are boiled with the colour for an hour or an hour and a-half, no mordant being used. The quantity of ware is varied according to the depth of shade of bottom required. 16 lbs. of camwood or 12 lbs. of cudbear for 100 lbs. of wool are good proportions for a full bottom.

Of course the blooming is not the only object which the dyer has in view; economy of indigo is an important matter to him.

It is important that the goods to be dyed should be thoroughly cleansed from all dirt, grease, and soap, or otherwise the dye will be taken up unequally.

Setting the Woad Vat.

The following is the method adopted in the woollen districts of the West Riding :—

Dimensions of Vat, 7 ft. diameter by 7 ft. deep.—Materials.

	£	*s.*	*d.*
5 cwt. Lincolnshire madder, at 26*s.*	6	10	0
3 pails of bran, weight 18 lbs.	0	1	1
22 lbs. slaked lime in dry powder	0	0	2½
2½ lbs. madder	0	0	10½
24 lbs. of indigo, at 5*s.*	6	0	0
	£12	12	2

The woad is chopped and pounded with a spade until the pieces are no larger than a hen's egg. It is thrown into the vat, which is then nearly filled with water. The contents are now heated by turning on the steam, until a temperature of 140° to 150° Fah. is obtained. The vat is stirred up three or four times at intervals of fifteen minutes, and then left overnight. The woad will now be soft and pulpy. Next morning put in the bran, madder, indigo reduced to a smooth paste by grinding, and half the lime; rake up, cover over, and leave till next morning. If the fermentation has commenced, the vat will present the following appearances :—A slight froth will rise to the surface when the bottom is slightly stirred with one rake. The liquid, when stirred, will appear green yellow with blue veins or streaks, the green colour predominating. A coppery blue scum called "flurry" will appear on the surface of the vat. A portion of the bottom drawn up with a rake will show signs of fermentation, and will smell slightly sour. A piece of wool put into the liquid for a short time will be dyed. If these appearances present themselves the vat is progressing favourably, and about a quart more lime may be added, and the whole well raked up. If no signs of fermentation appear, more time must be given before adding the lime, which in this case would only have the effect of retarding the fermentation. If the vat matures satisfactorily, a quart more lime may be added every two or three hours, stirring up well after each addition. The coppery blue flurry will increase in quantity, and the liquid, when stirred, will be green yellow with blue streaks. Then heat up to 140°, cover, and leave overnight. Next morning (the third morning), if the fermentation has proceeded satisfactorily, the vat may be used for dyeing. It is very important that great caution should be exercised in the addition of lime, for if the vat be overdosed fermentation will be arrested, and there will be considerable difficulty in re-establishing it. The vat will then have to be left probably for several days before the fermentation reappears. On the other hand, if the addition of lime be neglected too long, and the fermentation passes to the putrid stage unchecked, the indigo will be lost, or, as the dyers say, it will "run away." The liquid exhales an agreeable odour when the progress of the setting is proceeding satisfactorily, but the odour changes when too much or too little lime is present. Much depends on the care and skill of the dyer, for no description of the process can accurately convey to the mind of the uninitiated the mode to be adopted in the varying conditions to which the fermenting indigo vat is subject. An experienced indigo dyer can exercise perfect control over the condition of his vat.

The following account of the setting of two indigo vats last week, of which I took notes, may be useful :—

The vats were intended for the dyeing of broad cloths and wool of a full blue.

Dimensions of vats, 6 ft. 6 in. by 6 ft. 6 in. On Wednesday, at noon, the vats were filled with water, and 4½ cwt. of crushed woad were put into each vat; the liquid was heated to 140° Fah., and stirred up once. On Thursday morning they were heated up again to 140°, and kept at that temperature all day. During the day they were raked up vigorously by four men four times. At five o'clock, p.m., 25 lbs. of indigo, well ground to a smooth paste, 14 lbs. madder, 5 quarts of lime, and 4 pails of bran (2 gallons each), were added, and the whole well stirred up and left overnight. On Friday morning at nine o'clock a light froth rose on the surface when the vat was gently stirred up with one rake. The bottom was in a slight state of ferment and smelt rather sour. The liquid appeared green yellow on the surface with blue streaks when it was stirred by the hand. (Sample of wool dyed in it exhibited.) One quart of lime was added to each vat, and the contents well stirred for ten minutes as before. It was then covered up. At 11 a.m. and at 1 p.m. another quart of lime was given, and the contents raked up as before. A considerable quantity of coppery blue flurry had now accumulated on the surface, and the liquid appeared of a dark greenish yellow with blue streaks when disturbed by the hand. The odour was favourable and the fermentation steady, being kept under by the lime. At 3 p.m. the vats were warmed to 135° and another quart of lime added and again well stirred up, appearance and odour favourable as before. At 5.30 the vats were in a condition fit to use for dyeing. (Sample dyed exhibited.) Three pints of lime were given to each vat and 5 lbs. more indigo; they were well stirred up. Temperature 130°. They were covered up and left overnight. At 9 a.m. on Saturday two sixty-yard pieces of narrow doeskins were put into each vat, and after they had been worked for 1¼ hours I took off a sample and left them. (Sample exhibited.)

The Dyeing Operations.

Pieces to be dyed a full blue are hawked in a strong vat from twenty minutes to two hours, according to the class of goods—heavy and closely woven fabrics requiring more time for the colour to penetrate into the centre than lighter and more open goods. The material is then drawn out of the vat, and after exposure to the air for some time, in order that the reduced indigo may become oxidized and pass into the blue and insoluble condition, the goods are passed into a weaker bath to dye up to the shade required. For light-blue colours, such as are given for woading for blacks, a single working through a moderately weak bath for about twenty minutes will be sufficient.

For dyeing wool, a vat which shows the fermentation to be in a moderately active state is found to be the best, but pieces are dyed more perfectly in a vat in which the fermentation is kept under.

When the goods are withdrawn from the vat, they are of a fine green colour, which rapidly passes to blue. The green colour is due to the instant oxidation of a portion of the yellow coloured reduced indigo, which thus produces a mixture of blue and yellow.

The formation of indigo blue from the reduced indigo is explained by the following equation :—

$$\underset{\text{Indigo white.}}{C_{16}H_{12}N_2O_2} + \underset{\substack{\text{Oxygen}\\\text{from the air.}}}{O} = \underset{\text{Indigo blue.}}{2C_8H_5NO} + \underset{\text{Water.}}{OH_2}$$

For keeping up the strength of the vat, about 15 lbs. of indigo are added every other day, more lime and bran being added every day. After finishing the day's working of the vats the necessary addition of bran, lime, and indigo is made, and the vats well raked up and heated up to 140° Fah.

The following table gives the quantities and cost of materials used in a large dye-house, for the woad vat for dyeing dark indigo blues on cloth. (Sample exhibited) :—

	£	s.	d.
6,533 lbs. indigo, at 5s. 6d. per lb. . .	1,796	11	6
68 cwts. lime, at 1s. per cwt. . .	3	8	0
19¾ packs bran, at 14s. 6d. . . .	14	6	4
142½ lbs. madder, at 4¼d. . . .	2	10	6
56½ cwts. woad, at 30s. . . .	84	15	0
12 cwts. fuller's earth	1	16	0
	£1,903	7	4

Percentages of total cost :—

Indigo	94·37
Fuller's earth	·10
Woad	4·45
Madder	·13
Bran	·76
Lime	·18
	99·99

Cloth dyed with the above materials, 159,180 lbs. Cost per pound, 3·67 pence.

It is noteworthy that the materials required to reduce the indigo only cost 5·52 per cent. of the whole.

Schutzenberger and Lalande Vat.

This vat stands in marked contrast to the woad vat already described, as regards time and the number of vats required. The reduction of the indigo is almost instantaneous ; in fact, the reduced indigo may be prepared beforehand, and then it is only necessary to add it to the vat, and proceed with the dyeing in the manner already described. The reduction is performed in the following manner:—

Materials required.—Bisulphite of soda, at 45° Tw., costing 9s. per cwt. Zinc dust, at 23s. per cwt. Slaked lime in powder, sifted, or in the form of cream of lime. Indigo, ground in water, in the form of pulpy paste, without any gritty particles.

Utensils for the preparation of the reduced Indigo.—A small tub, or pail, in which to prepare the hydrosulphite. A cask in which the indigo is reduced. Barrels in which to store the reduced indigo. The same vats and utensils which are employed with the woad vat.

To prepare the reduced indigo proceed as follows:—

Pour bisulphite of soda solution into a pail or small tub, and add zinc dust until the smell of sulphurous acid disappears, stirring up well until this takes place. The zinc dust required will be from one-fifteenth to one-tenth of the weight of the bisulphite of soda. The solution so produced is called hydrosulphite.

Place your indigo paste in a cask or tub; add a little cream of lime, and heat to 120° Fah. Run in sufficient hydrosulphite to reduce the indigo, which may be known when the surface of the mixture assumes a dark green appearance ; then add more cream of lime to dissolve the reduced indigo, when the mixture then becomes yellow. It may be known when sufficient lime has been added by taking out the stirring rod, which will quickly assume a bronzed, coppery appearance. If too much lime has been added, the indigo becomes brown and is partly destroyed, a smell of ammonia being given off.

The creamy fluid is then run into barrels for use.

The principle on which the indigo is reduced has already been given. (A small sample of indigo was reduced.)

The Dyeing Operations.

The vat is filled up with water, which is heated up from 130° to 140° Fah., and the necessary quantity of reduced indigo run in from the store casks. The dyeing may be carried out exactly on the same plan as with the woad vat ; the vat may, however, be used continuously, as it may be fortified at any moment by the addition of reduced indigo. If the indigo in the vat should become oxidized by exposure to the air, and by the air which the goods carry in with them mechanically, it may be reduced by adding hydrosulphite, and also lime, if necessary, to the vat. As there is not such an accumulation of solid matter at the bottom of the vat as there is in the woad vat, vessels having a much less depth may be employed.

The dyer very quickly learns how to manage this vat. The operations are simple and perfectly under control, and they do not, therefore, require an apprenticeship to learn how to manage them, as is the case with the fermentation process.

Opinions of Dyers on the Hydrosulphite Vat.

Since the year 1873, when it began to be used in Yorkshire, the experiences of woollen dyers with this vat have been very varied. It has been abandoned by some and continued by others.

The advantages claimed for it are—that it is easy to manage; that it dyes worsted goods clean; that it can be used either for light or dark blues; that the services of an experienced blue dyer at high wages can be dispensed with; that it is rapid.

The disadvantages attributed to it by those who have abandoned it are—that it is much more expensive than the woad vat on account of loss of indigo in washing; that the goods handle thinner when of the same weight and texture, although the strength of the goods is not impaired, as tested by Hebden's machine ; that the colour is not quite so good, being somewhat green; that it requires one-third more red bottom than the woad vat; that it spoils the face of goods.

The heaviest charge against it, however, seems to be the cost, but this may be very greatly lessened by recovering the indigo which washes off, by passing the goods through milk of lime before the washing. The lime dissolves the reduced indigo which has not become fixed to the fibre. The green colour can be removed by passing the goods through very dilute sulphuric acid in the washing machine.

The following table gives the cost of dyeing dark blues by the hydrosulphite vat by a dyer who wished to use it, but was deterred by the cost. It bears unfavourable comparison with the cost of materials by the woad vat. The cost of labour in working the two vats may be assumed to be about the same :—

		£	s.	d.
240 lbs.	Indigo at 5s. 6d. . .	66	0	0
1,978 lbs.	Bisulphite of soda at 1d.	8	4	10
195 lbs.	Zinc dust at 23s. per cwt.	2	0	1
30 lbs.	Fuller's earth . . .	0	1	0
	Lime	not given		
		£76	5	11

Percentages of total cost :—

Indigo	86·84
Bisulphite soda	10·62
Zinc dust	2·63
Fuller's earth	nil.
Lime	not given
	100·09

Cloth dyed with above material, 3,420 lbs. Cost per lb., 5¾d.

The materials required to reduce the indigo cost 13·25 per cent. of the whole.

(Wool and swatches of cloth were then dyed with the hydrosulphite vat.)

Extracts of Indigo (Indigo Carmine).

These are sulphuric acid derivatives of indigo obtained by dissolving indigo in strong, or even fuming, sulphuric acid. The extract having a purple colour, contains chiefly sulphopurpuric acid, $C_{16}H_{10}N_2O_2,SO_3$, the blue extract contains sulphindigotic acid, C_8H_5NO,SO_3. The production of these two varieties depends upon the strength of the acid used, and the temperature and time of contact.

The acid, or "sour extract," may be made by gradually adding 1 lb. of well-powdered indigo to 12 lbs. of the strongest commercial sulphuric acid, stirring well during the addition. The mixture is then kept for two days at a temperature of about 140° Fah. A little of the mixture dropped into water should completely dissolve. The mixture is poured into water, and is then ready for use. The best qualities of indigo and the refined article should be used in these preparations.

The sweet extract is made by neutralizing an acid extract with carbonate of soda and chalk, adding also salt. The sulphopurpuric and sulphindigotic acids form soda salts, which are insoluble in solutions of alkaline salts; the colouring matter can therefore be precipitated, filtered off, and washed. The following process gives a good sweet extract:—Add gradually 9 lbs. of the strongest sulphuric acid to 1 lb. of the finest quality of indigo finely ground and sifted, stirring well all the time ; set aside for a week at from 60° to 70° Fah.; then add a solution of 10 lbs. of common salt and 15 lbs. of soda crystals; then ½ lb. of powdered chalk may be added, and the whole

well stirred up and thrown upon a filter, and washed with a solution of salt till the washings run through colourless.

The purple extract is made by using one-third as much acid and leaving them in contact only a short time.

These dyes require no mordant for wool; they dye best in an acid bath, and the addition of sulphate of soda is found to be beneficial in clearing the liquid and producing evenness of shade.

They are not used as self colours on woollen goods, but enter largely into the composite colours of goods which do not require to be scoured afterwards.

They are not, therefore, fast colours, and cannot be compared with indigo colours dyed by vat processes, which possess a degree of permanence which has long given them a deserved popularity, as they remain unaffected alike by heat and cold, sunshine and rain, acid and alkali.

A CIGAR SCIENTIFICALLY DISSECTED.

AN POLITE visitor, who, during his interview with us, had rendered our sanctum redolent with the fumes of a fragrant Havana, has just left a cigar on our table with the laughing request that we smoke it. Despite the fact that it is an exceptionally fine cigar, we are unable to gratify our friend's desire, seeing that we don't smoke; but the thought occurs that we can show our appreciation of the gift by applying the light, not of a match, but of science, to it, and thus giving our friend and his brother smokers something to ponder over next time "the blue up-curling smoke" leads them to reverie.

To the world in general a cigar is merely a tightly rolled packet, having brittle fragments of dry leaves within and a smooth silky leaf for its outer wrapper. When it is burnt, and the pleasantly-flavoured smoke inhaled, the habitual smoker claims for it a soothing luxury that quiets the irritable nervous organism, relieves weariness, and entices repose. Science, scouting so superficial a description, examines first the smoke, second the leaf, third the ash. In the smoke is discovered water in a vaporous state, soot (free carbon), carbonic acid and carbonic oxide, and a vaporous substance condensable into oily nicotine. These are the general divisions, which Vohl and Eulenberg have still further split up; and in so doing, have found acetic, formic, butyric, valeric, and propionic acids, prussic acid, creosote, and carbolic acid, ammonia, sulphuretted hydrogen, pyridine, viridine, picoline, lutidine, collodine, parvoline, coridine, and rubidene. These last are a series of oily bases belonging to the homologues of aniline, first discovered in coal tar. Applying chemical tests to the leaves, other chemists have found nicotia, tobacco camphor, or nicotianine (about which not much is known), a bitter extractive matter, gum, chlorophyll, malate of lime, sundry albuminoids, malic acid, woody fibre, and various salts. The feathery white ash, which in its cohesion and whiteness is indicative of the good cigar, yields potash, soda, magnesia, lime, phosphoric acid, sulphuric acid, silica, and chlorine. Our friend has kindly left us a fine cigar; had it been a poor and cheap one the ingredients we should extract would be fearful and wonderful to contemplate. Here is the list from an English parliamentary report on adulterations in tobacco: Sugar, alum, lime, flour or meal, rhubarb leaves, saltpetre, fuller's earth, starch, malt commings, chromate of lead, peat moss, molasses, burdock leaves, common salt, endive leaves, lampblack, gum, red dye, a black dye composed of vegetable red, iron, and liquorice, scraps of newspaper, cinnamon stick, cabbage leaves, and straw brown paper.

Returning now to the smoke, or rather its ingredients, Dr. B. W. Richardson, in his "Diseases of Modern Life," considers the effect of the same on the body at considerable length, basing his conclusions on actual investigation. He tells us that water, of course, is harmless; free carbon acts mechanically as an irritant, and tends to discolour the secretions and the teeth. Ammonia bites the tongue, exercises a solvent influence on the blood, excites the salivary glands, and thus causes a desire to drink while smoking. The tendency of carbonic acid is to produce sleepiness, headache, and lassitude. When a cigar is smoked badly, that is, when the combustion of the tobacco is slow and incomplete, carbonic oxide is produced in small quantities, and is an active poisoning agent, resulting in irregular motion of the heart, vomiting, convulsions of the muscles, and drowsiness. The nicotine tends to cause tremor, palpitation of the heart, and paralysis. The volatile empyreumatic substance produces a sense of oppression, and taints the breath and surroundings of the smoker with the well-known "stale tobacco smoke" smell. The bitter extract causes that sharp nauseous taste peculiar to a relighted cigar or an old pipe.

By trying the effect of tobacco smoke on lower animals, we can obtain an idea of its influence on ourselves. Small insects are stupefied rapidly, but recover in fresh air. Cold-blooded animals succumb slowly to the smoke—birds rapidly. Some animals—such as the goat—can eat tobacco with impunity, but none escape the effects of the fumes. Persons suffer most from tobacco while learning to smoke. Dr. Richardson says that the spasmodic seizures are sometimes terrible, especially in boys. There is a sensation of imminent death, the heart nearly ceases to beat, and sharp pains shoot through the chest. Examination of inferior animals under such conditions shows that "the brain is pale and empty of blood, the stomach reddened in round spots, so raised and pile-like that they resemble patches of Utrecht velvet." The blood is preternaturally fluid, the lungs are as pale as those of a dead calf, and the heart is feebly trembling. Such is the primary action of one's first cigar.

After a time, however, the body becomes accustomed to the influences of the poison; and with the exception of constant functional disturbances (owing to the excretory organs, notably the kidneys, being compelled to do work not essential to their duties), no distressing results are felt. There are numerous instances where the evil effects are scarcely appreciable, the physical and nervous constitution of the smoker being capable of resisting the influence. In many cases, copious salivation attends smoking; and in this circumstance the opponents of tobacco have found a strong argument. Still, either to expectorate or not to do so is a choice of two evils. In the latter case the result is to swallow the saliva charged with poisonous matter; in the former, the saliva needed to prepare food for digestion is lost; and besides, as it contains salts of lime in solution, the effect is to produce large formations of tartar on the teeth. "Smoker's sore throat" is a special irritable state of the mucous membrane, induced by cigar smoking, which soon disappears when the habit is broken off. Tobacco smoke does not produce consumption or bronchitis, but it tends to aggravate both maladies. Its effect on the organs of sense is to cause, in the extreme degree, dilation of the pupils of the eye, confusion of vision, bright lines, luminous or cobweb specks, and long retention of images on the retina, with other and analogous symptoms affecting the ear, namely, inability to define sounds clearly, and the occurrence of a sharp ringing sound like that of a whistle or a bell. Its effect on the brain is to impair the activity of that organ and to oppress it, if it be duly nourished, but to soothe it if it be exhausted. It leads to paralysis in the volitional and in the sympathetic or organic nerves, and to over-secretion from the glandular structures. Science was not wise enough to prepare so formidable an indictment of the nicotian weed as the above in King James's time, else that monarch might have had better ground than his personal dislike for stigmatizing the habit of smoking as a "custom loathsome to the eye, hateful to the nose, harmfull to the braine, dangerous to the lungs, and in the black stinking fume thereof neerest resembling the horrible Stigian smoake of the pit that is bottomlesse."

And yet, despite all that Science can say, the habit is increasing. Two centuries ago the Turks regarded smoking as a religious offence, and paraded a smoker through the streets of Constantinople with his pipe stuck through his nose as a warning to others. Who can disconnect the Turk now from the ideas of chibouque or nargileh or fragrant Latakia? Look at the best cigar wrappers the world can produce, raised on tobacco fields in the heart of New England, where the Puritan Fathers once visited the direst of Blue Law vengeance on the wretch who profaned his Maker's handiwork by "making a chimney of his nostrils." The value of our tobacco crop last year reached nearly $30,000,000. We consume annually some 75,000 hogsheads of the leaf; we imported about 83,000 bales of cigars, etc., from Cuba in 1875.

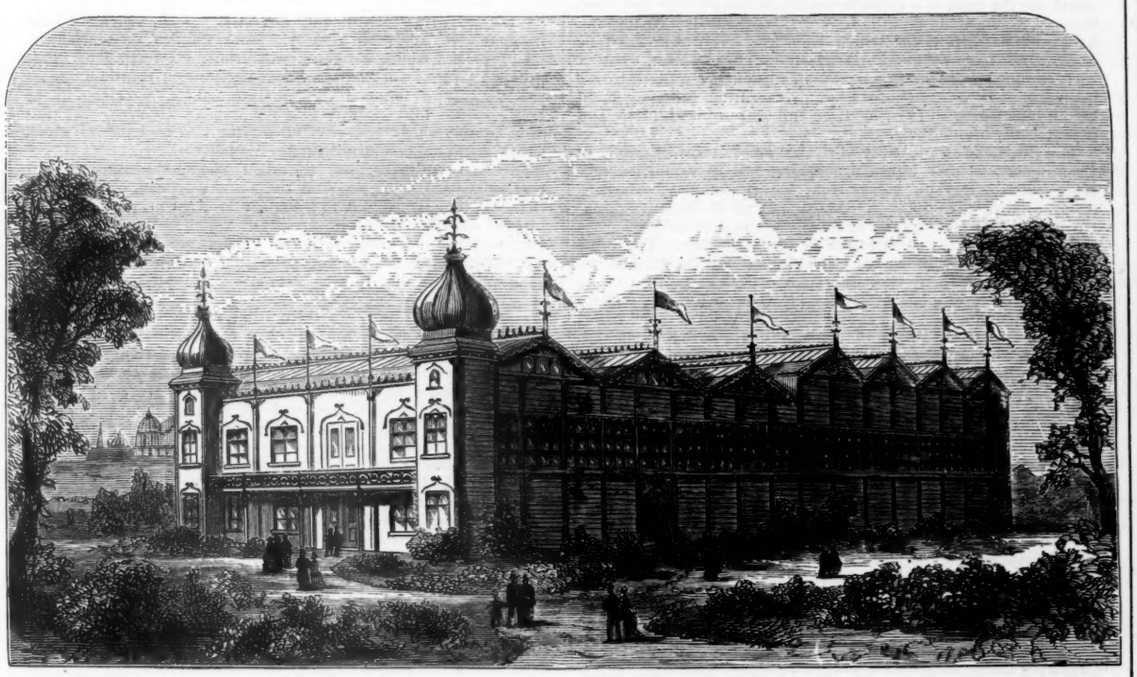
What is the end of it all? Effects on individuals likewise affect communities; these in turn influence the nation. No person that smokes can be in perfect health, and an imperfect organism cannot reproduce a perfect one. Therefore it is logical to conclude that, were smoking the practice of every individual of a nation, then that people would degenerate into a physically inferior race. It would follow, moreover, that in those countries where smoking is most practised a lower physical, and a consequently lower intellectual, development must be found. Such, we think, will be conceded to be true of Spain, of Cuba, of Portugal, of Turkey, of Greece, and of the South American countries, where those who are addicted to the habit vastly outnumber those who do not smoke. *Scientific American.*

SOUTH AFRICAN INTERNATIONAL EXHIBITION, 1877.

AFRICA, from being the land of lakes, jungle, and slaves, is now the continent of hopeful enterprise. The civilizing labours of travellers and missionaries have at last told upon the natives, and the cordon of barbarous habits has been broken. Its physical geography is also better known than when Mungo Park, Burckhardt, the Landers, and Clapperton traversed its then untrodden wilds, and came back to England with their story, or, sending that story home, died, like Lander and Mungo Park, in the lands they had discovered.

In the PRACTICAL MAGAZINE it would be out of place to recount the soul-stirring story of adventure. Our labours must be confined to the department of progress which concerns the engineer, the manufacturer, and the enterprises of applied science.

The announcement of a South African Exhibition, to be opened in February next year, is alone an astonishing evidence of the expansion which has been going on for the last twenty years, is increasing in momentum every day, and is apparently illimitable. The enlightened ruler of Egypt in the north, that still more European ruler at Zanzibar, and the Christian Society at the Cape of Good Hope, with the foreign consuls, are so many guarantees for the protection of enterprise and adventurers, besides assisting by their influence and direction in removing prejudices, upheaving bad customs, and inspiring confidence in the natives towards the stranger—an element absolutely essential in any modern undertaking, whether as regards the material or moral interests of a debased and isolated multitude "that no man can number." The time is past for the sword to precede the plough. Science and machinery exhibit astounding feats, calculated to excite the wonder of savages, and to manifest even to those dull eyes the superiority of the white man. The steam vessel now traverses waters that have borne the stout-hearted lonely missionary in a little boat, and the merchants go in routes which are gradually being absorbed into the catalogue of international highways, whereon we shall hope to see the iron roads of Europe and the horseless power of Watt. There is happily an increasing class of Englishmen devoting themselves to the calling of the practical engineer, and it will be a long time before their market is crowded. The demand for such services will for the most part be made upon the able men of England, not only from the variety of experience they obtain in their education, but because our insular climate makes the healthy Briton the best able to endure the fatigues and hardships of strange climes.



SOUTH AFRICAN INTERNATIONAL EXHIBITION, 1877.

Recently there has been another project which will excite interest and provide occupation for the engineer. We refer to the proposal to open a communication from the sea to one of those enormous lakes which abound in the interior of the African continent. It is an undertaking alike attractive to the engineer and the men of science who are engaged in the study of atmospheric phenomena with a view to remove the causes of destructive fevers and malaria; for not only does it involve many novel problems arising from difficulties of construction which would have to be overcome, but a vast region hitherto uninhabitable will be transformed into the very healthiest district of the continent.

But it is to the future the young student must look; it is from the future the machinist should expect to reap the harvest of the seed sown now. What machines are sent will in all probability be disposed of, and open a market for future consignments. Colonial trade is very much dependent on introductions, and the house that establishes a priority in the market is likely to have precedence in the orders for many years. So it is with machinery. What one colonist ascertains from experience is suitable to his tract his neighbour or friend will prefer, simply because he does not want the trouble of testing relative merits. He would rather take what is evidently safe than incur the risk of disappointment.

Again, with regard to invention, there is a large field open for engineers and inventors in the supply of strong, rough, and cheap machines for agricultural work. Where labour is scarce and dear, and the exigencies demand rapidity of operation, machines are essential. But it often happens that the colonist is without sufficient spare money. If he can buy a machine on the same principle as that he selects, but of rougher finish, he will buy; but if he cannot purchase on those conditions he will do without, and take the risk of dispensing with machine aid altogether. There is a strong demand for lower-price machines, which probably are the best adapted for the species of cultivation most available in the colonies, and this demand must increase.

We have supplied an engraving of the building to be erected near Cape Town for the Exhibition in February, 1877; but it is best to acknowledge that, in the face of the many applications

for space from England, France, and America, there is no doubt of a system of annexes being added. The firm of Clayton and Shuttleworth, of Lincoln, can of themselves completely fill one, and the same can be said of Ransome and Sims; and not only is this remark of value as respects agricultural machines, of which we gave many illustrations in our issue for July, 1876, but there is the whole mechanism connected with cranes and lifters, and the ever-widening field of steam-engine manufacture, donkey engines, horizontal engines, and an army of inexpensive items, conducive to the profit of the investor without in any way interfering with the status of the labourer or the labour market of the colony.

It must be remembered that for many years the Cape has been very dependent on the Indian and Australian trade, and that during the last few years much of that trade has been diverted by the opening of the route through the Suez Canal. This will have, and is having, a beneficial effect on the self-reliance of the colonists. They have been living snugly enough in their little corner; now they must go forth and conquer the land. Table Bay cannot be removed, and no other harbour can equal it. Cape Town cannot be removed, and it stands on the apex of a triangle which, on the western line, runs through Malmesbury and Clan William, and on the east through half-a-dozen districts to British Kaffraria. Railways must be made which must eventually penetrate into the interior. Under such circumstances the practical man who makes a mark by his invention or by his machines has a certain trade or engagement before him which will last his time and that of his children, and is practically a monopoly.

The Sheffield trade may fairly be associated with that of Birmingham in this industry. Galvanized iron pulleys, fire-proof safes, telegraph wires, tram wires, and the numerous forms of wire manipulation for fencing, all of ingenious construction, and which can be specially adapted to colonial uses, will be a prominent department in the collection. We hope that the display will contain novelties of special adaptation. There is a wide field open for such experiments, as can be proved by the example of Australia, for whom machinists, inventors, and manufacturers have done their best to meet the peculiar conditions of colonizing and subjugating a savage and rich country. The Cape of Good Hope offers a region of as good a prospect; indeed we incline to think it better, because it is really new ground and capable of becoming a new market. Colonists do not want to have merely what may find favour in Great Britain; they would, all things being equal, prefer that their machines should be constructed or contrived with reference to their particular requirements; and therefore a new field is open to the home producers, which at this Exhibition we much hope to see occupied. If we at home supinely neglect this, little Belgium will not, France will not, neither will Brother Jonathan. We have had some trouble as a nation with the Cape Colony; and as colonies are cherished chiefly for their commercial value, it would be a dishonour to the mother land if she permitted strangers to rush in and draw a harvest that by nature and right should be our possession.

The Exhibition is divided into ten classes, and several of these are not within our range; but all are selected with a view of furthering the development of enterprise and commerce, to which result there is no doubt they must lead by rapid strides. Nature has stored inexhaustible wealth in the vast continent of Africa, and enterprise and commerce, machinery and railways, form the best civilizers that the colonists can employ, as well as certain means to the accumulation of wealth and power.

The Agricultural Section will receive much attention from the colonists, and to it the best men of our country are willingly sending their samples. Picks, ploughs, harrows, drills, chaff-cutters, gates, hurdles, rollers, mowers, cattle foods, artificial manures, are amongst the articles to be exhibited, besides the array of steam machines previously referred to.

This International Exhibition comes very opportunely. Trade has grown during the past twenty years, in spite of all the difficulties, to three times its value in 1856. The attention of the colony is, as is well known by the loan obtained here of four millions, attracted by railway enterprise, and with that money 800 miles are being constructed, aided by the sale of public lands; and out of the 800, 120 miles of one line are being worked. The intercourse with England is now weekly, and the transit occupies about twenty days. True, they have not as yet a telegraph connecting this country to theirs, although there will soon be a submarine one to join that at Madeira; but there are 2,000 miles of interior telegraph wire. The country is so vast that such figures are nothing. We heard the other day about troubles in the Transvaal. Why, that is many hundred miles from Cape Town, and will probably come under the British Crown, being the outskirt of present colonization. The prospect to engineers and inventors of machines, and to those who have to do with the chemistry of nature, is one of the grandest that modern colonization has ever yet known. Surpassing Australia in promise, the Cape will soon be found the richer harvest for the emigrant; and thus the pressure of hard times and competition at home will find its relief in the good old way of sending the children away from home.

We have only to add, for the information of our readers, that there is no time to be lost. If they know anything worth telling, or can do anything worth doing, in connection with the work in hand, the European office is at 3, Castle Street, Holborn, and Mr. Edmund Johnson, who is known to the public by many an enterprise, and who has successfully represented the interests of Englishmen at the Brussels and the Philadelphian Exhibitions, is to be relied upon for truthful information and prudent counsel.

"AIR AND ITS COMPONENT PARTS."

UNDER this title Dr. C. Bender has furnished the following remarks to a foreign contemporary, which we think will prove interesting to many of our readers, hence the present reproduction:—

It was already maintained by Aristoteles in the fifth century that air was an element. At that time, by the word "element" all matter was understood which in any way contributed to general existence.

Air was, however, not the only element recognized, for fire, water, and earth enjoyed the same privilege. These four elements then, combined in the most different proportions, constituted all tangible forms and were assumed to be absolutely necessary for the continuation of existence. The elements of the ancients were not taken to be actual matter, but it was only the certain and non-varying properties of matter which led to the conception of the word "element." Thus the property of the atmosphere to sustain respiration, which was necessary to life, caused it to be taken as an element, for it was, so to speak, the base of all animal existence. Perhaps, when viewed in this light, the air we breathe might be still taken as an element of human existence, although modern science has greatly restricted the meaning of the word thus used. At the present time the body or base itself is looked upon as being of the greatest importance, whereas the properties inherent thereto are viewed in a secondary manner. Thus by the word "element" we understand a body or matter which, despite of all chemical analysis, cannot be decomposed into other conceivable matter.

The atmosphere, however, which presents itself to our organs as one compact whole, is nevertheless decomposable. We are enabled to divide the atmosphere, or to express ourselves more clearly, to extract certain component parts of the air, which parts are no longer further decomposable. One of these component parts, and by far the most important, of our atmosphere, goes by the name of "oxygen," an element which was discovered by Priestley in 1774. The same discovery was independently confirmed by a Swedish *savant* of the name of Scheele. To the Frenchman Lavoisier the honour is, however, ascribed of having alone proved the properties of this interesting body.

Professor Brande, in his refined dissertation on the progress of chemical science, rightly observes to the following effect:—The 1st of August, 1774, is a *red-letter day* in the annals of chemical philosophy, for it was then that Dr. Priestley discovered dephlogisticated air. Some, sporting in the sunshine of rhetoric, have called this the birthday of pneumatic chemistry; but it was even a more marked and memorable period; it was then that this branch of science, having eked out a sickly and infirm infancy in the ill-managed nursery of the early chemists, began to display symptoms of an improving constitution, and to exhibit the most hopeful and unexpected marks of future importance. The first experiment which led to a very satisfactory result was conducted as follows: A glass jar was filled with quicksilver and inserted in a basin of the same; some red precipitate of quicksilver was then introduced and floated upon the quicksilver in the jar; heat was applied to it in this situation with a burning-lens, and, to use Priestley's own words, "I presently found that by means of this lens air was expelled from it very readily. Having got several times as much as the bulk of my materials, I admitted water to it, and found that it was not imbibed by it. But what surprised me more than I can well express was, that a candle burned in this air with a remarkably vigorous flame, very much like that enlarged flame with which a candle burns in nitrous air exposed to iron or liver of sulphur; but as I got nothing like this remarkable appearance from any kind of air besides this par-

ticular modification of nitrous air, and I knew no nitrous acid was used in the preparation of mercurius calcinatus, I was utterly at a loss how to account for it."

Although oxygen is contained in our atmosphere, still we are not able to produce it directly, for the reason that no body has the property of so combining itself with the oxygen of the air, that oxygen itself will merely remain. The conclusion might be easily drawn from this remark, that we were not in a position to extract the oxygen from the surrounding air; but correct as this is in one direct sense, still by going indirectly to work we are enabled to accomplish this task. These means are adduced from the property oxygen has to combine itself with other bodies under various temperatures, in which second instance oxygen is regenerated; such a body, for example, is "quicksilver." Namely, if metallic quicksilver be somewhat heated during a certain time, under access of air, it becomes changed into a red body, which is a combination of quicksilver and oxygen, and is therefore named "quicksilver oxide." If this "mercurius præcipitatus per se," as the latter was called by the ancient alchemists, be further heated, a second decomposition of this red substance takes place, and quicksilver and oxygen are formed afresh. This experiment proves, therefore, that we are not only able to obtain pure oxygen from the air, but that moreover we can easily determine how much oxygen is contained therein. The last assumption becomes all the more evident if we suppose that in the carrying out of the before-mentioned experiment, we had allowed a certain quantity of air—the volume of which had been exactly determined—to be in contact with the heated metallic quicksilver, and that we had further so contrived our arrangements that the admission of more air was impossible; then, by having a sufficient quantity of the quicksilver, the latter absorbing all the oxygen contained in the surrounding air, a diminution of volume will be the result. The difference between the known volume of air, at the commencement of the trial, and the volume of air presenting itself at the finish of the experiment, will therefore give us the cubical proportion of pure oxygen contained in our atmosphere. This experiment has the further advantage that we are enabled to check the correctness of the previous calculation indicated, for we need only subject the red substance (quicksilver oxide) to great heat, and the absorbed oxygen is thrown off again in a pure state. Therefore, if we collect this "emesis," and measure it, we thus obtain a sure check on the correctness of our former calculations. By means of this experiment the before-mentioned Lavoisier found that for every 100 cubical parts of the atmosphere, about twenty-one parts were taken up by oxygen.

The production of oxygen from red quicksilver is thus of great theoretical moment. If it be desired to produce it quickly and in large quantities, other methods may of course be adopted. One of the most agreeable of these is as follows:—If chlorate of potash be taken and heated in a retort, the salt melts, and a rapid development of gas is the result. This gas is oxygen, as can be readily proved by dipping a lighted taper into it, when deflagration takes place. The production of oxygen may be rendered easier by adding to the chlorate of potash some sand or finely powdered manganese or oxide of copper instead. By mixing them well together and subjecting them to a gentle heat the generation of gas is much more rapid.

Oxygen gas is heavier than the atmospheric air, having a specific gravity of 1·1056. The affinity of water for oxygen at its greatest density (7° Fahr.) is expressed by the proportion of 1,000 : 37.

Proceeding to the properties of oxygen, as far as they are of moment to the subject under discussion, we have already alluded to its "deflagrating property," which is a chemical process known under the name of "combustion." Generally speaking, therefore, we understand by combustion a combination with oxygen.

This process of combustion may show no appreciable signs of change to the superficial hasty glance, and under such circumstances the combination with oxygen is said to be "slow," and the temperature is "low." To produce intense luminosity and heat we must first impart a high temperature to the combustible body, and the temperature which is required to effect this is called the "temperature of ignition." For instance, phosphorus possesses a very low "temperature of ignition," for we need only bring it in contact with a slightly heated body to enable it to take up the oxygen, and we observe at the same time intense luminosity and heat evolved.

We are therefore aware that all combustions or conflagrations taking place in the open air are effected at the cost of the oxygen contained in the atmosphere; but as the latter is composed of other bodies besides oxygen, the phenomena of combustion must be of greater intensity in pure oxygen, which is in fact conclusively proved in practice. A piece of ignited charcoal, for instance, when left by itself to the action of the air is soon extinguished, but burns again with greatly increased vigour when dipped in oxygen. The product of combustion is the gaseous carbonic acid, which presents itself also in effervescing drinks. The atmosphere likewise contains this gas, but in very slight proportions, 1,000 parts of air showing but two to three parts of carbonic acid. This last-mentioned fact is easily explained, for with the combustion of any body containing carbon, carbonic acid must necessarily be generated. A further reason for this fact is the presence of animal life, the respiratory organs of which burn carbon inwardly into carbonic acid; or in other words, for the inhalations of the surrounding air we exhale carbonic acid.

This last-mentioned substance is a gas which cannot sustain animal life, animals and man succumbing in a short time to its deadly effects. When we think that in every moment of our lives we are producing this gas that is fatal to life, that for all the air we breathe we exhale almost the whole of the oxygen inhaled in the form of carbonic acid, and when we further reflect that a grown-up man daily consumes in 24 hours 746 gr. = 18,387,627 cubic feet of oxygen, and exhales on the other hand during the same time 867 gr. = 15,661,205 cubic feet of carbonic acid, we may thank our Maker that he has created other individuals which attract the heavy noxious gas, and in return emit the base of our existence, namely, pure oxygen. Such individuals are found in the vegetable world, and hence we recognize the usefulness of public parks and gardens in crowded cities, and detect the healthiness of country people.

Carbonic acid gas is a heavy gas, having a density of 1·529, or say 1½; that is, if a certain space filled with air weighs 2 lbs., the same space filled with carbonic acid gas would weigh 3 lbs. It is owing to this property that man is very seldom poisoned from its effects. In many places it issues from the fissures of the earth, as for instance in the Dog Grotto of Naples, and in such localities, where there is no air-current, it collects itself gradually on the ground. Despite of this wise law of Nature, we should carefully effect the absolute removal of the exhaled carbonic acid from our surroundings, and see that fresh air be supplied in place of the vitiated air. There can, of course, be no difficulty to effect this in open situations; but in enclosed rooms we must have recourse to suitable ventilating means, the importance of which has only been lately recognized in its full bearing. The presence of carbonic acid gas in the atmosphere may be easily proved by leaving lime-water in an open vessel exposed to its action. In a short time a white skin forms itself on the liquid, which soon sinks to the bottom; if the supernatant liquid be poured off, and if an acid be poured on the precipitate, effervescence will take place, owing to the presence of the carbonic acid gas. The precipitate is a combination of carbonic acid and lime, known under the name of chalk.

Experiments made by Saussure and Schlagintweit proved that the surrounding air of high mountains, at a height of 11,000 to 13,000 feet, contained more carbonic acid than the air of the valleys underneath, which is certainly a remarkable fact, considering the weight of this gas. It may, however, be attributed to the scarce growth of vegetation at such heights, which prevents the carbonic acid formed finding a sufficient quantity of plants to adequately absorb it. Observations have further proved that at night-time the presence of carbonic acid gas is greater on the surface than in the daytime, and also greater in summer than in winter. It is possible that plants again inhale oxygen and exhale carbonic acid during the night. On the other hand, a greater quantity of carbonic acid gas is found in the air at sea in the day than in the night-time.

It is now about two hundred years ago that an Englishman of the name of Mayow noticed that the air which remained after the combustion of an organic body, and which had also been treated with lime-water in order to remove the carbonic acid formed, possessed a lesser density or specific gravity. He also observed that this air would not support further combustion. At the time here referred to, all gases went under the name of "air," and consequently we find this gas described as air, with special properties enumerated. About a century ago, or in 1772, Rutherford discovered this peculiar air to be a distinctive component part of our surrounding atmosphere, and we consequently recognize Rutherford to be the discoverer of nitrogen, or azote gas. In the year before mentioned Dr. Rutherford, professor of botany in the university of Edinburgh, published a thesis in Latin on this fixed air, in which he says: "By the respiration of animals healthy air is not merely rendered mephitic—*i.e.* charged with carbonic acid gas—but also suffers another change. For after the mephitic portion is absorbed by a caustic alkaline lixivium, the remaining portion is not rendered salubrious; and although it occasions no precipitate in lime-water, it nevertheless extinguishes flame and destroys life."

Nitrogen may be produced directly from the atmosphere by treating a certain quantity of the latter with a substance readily combining with the oxygen of the air, while also absorbing the

minute quantity of air contained therein by lime-water treatment. Such an experiment has already been mentioned; namely, in producing oxygen gas indirectly from the atmosphere, it was observed that quicksilver heated for a considerable period in the atmosphere, formed itself into a red substance, whereas when closed up a diminution in volume resulted. The remaining gaseous body is *nitrogen*. However, quicksilver is not well adapted to the present purpose, since its combination with the oxygen of the air is too slow. Another substance is therefore substituted for the quicksilver, in the form of phosphorus, which combines much more readily with the atmospheric oxygen. If phosphorus be allowed to swim on water in an ignited state, and a bell-vessel is put over it, the water will soon begin to rise, and the phosphorus will cease burning. The smoke emitted soon ceases, and inside the bell nitrogen gas will be found. If a lighted taper be inserted in this gas, it will be immediately extinguished. But nitrogen may be obtained by various other means, as for instance by allowing atmospheric air to pass over red-hot copper shavings. The latter absorb the atmospheric oxygen, and the nitrogen may be collected by itself. Of course, if pure nitrogen is required, the air should be cleansed from its carbonic acid gas components; this may be done by passing the air first through lime water, before it passes to the copper shavings.

Nitrogen gas is lighter than atmospheric air, with a specific gravity of 0·9713. The atmosphere is the great storehouse of nitrogen, and four-fifths of its prodigious volume consist of this element. In a chemical view, nitrogen is not a very important body, but it performs a very agreeable function in connection with our atmosphere. Without its aid the oxygen of the surrounding air would convert our blood four times as quickly into carbonic acid gas; we should require four times as much to eat; our children would arrive at manhood in one-quarter of the usual time; in short, animal life would, under such circumstances, last but one-fourth of its time between birth and death, consequently nitrogen is a diluter of oxygen.

A further component of our atmospheric air is watery vapour, the presence of which may be easily detected. Many chemical substances extract water with great avidity, and such substances are then called hygroscopical bodies. One of these is chloride of calcium, another is hydrate of potash, and so on; if these substances are left exposed for a short time they melt away. Human hairs, for instance, are also very powerful hygroscopical bodies, and this property has caused them to be applied for meteorological observations, or as weather prophets. Concentrated sulphuric acid is another hygroscopical body, and if a jar be filled with it and allowed to remain open for several days, the watery vapours attracted and imbibed by it will in many cases cause it to ruh over.

We can easily account for the presence of watery vapours in our atmosphere, considering that two-thirds of the earth's surface are covered by water. This water is being continually converted into vapour by the well-known evaporating process; it need scarcely be remarked that a boiling temperature is not absolutely required for the formation of watery vapours, for water of 0° temperature, as well as snow and ice, will evaporate,—that is give off vapour to the surrounding air. As a proof of this, the observation is frequently made, that after snow falls, although the temperature may remain as low for a fortnight after, still at the expiration of this time, the snow will have passed away. It is very often erroneously supposed that the cause of this disappearance has been brought about through the imbibing of the earth, whereas the cause is due to its having evaporated in the form of vapour. These watery vapours furnish another natural phenomenon, which has certainly been admired by all men; this is the effect of the sunset, which is produced by the solar rays penetrating through a thicker atmospheric medium containing more vapour; these watery vapours have the property of allowing yellow and red beams to pass through, but the blue rays are reflected. A sunset is therefore always a sign of a vapoury (humid) atmosphere.

The humidity of the air varies with all situations. Generally speaking, it is greater in the warmer zones than in the colder zones, but the relative proximity of the sea makes, naturally, a wonderful difference. Warm air is able to imbibe more vapour than cold air; consequently in the summer time it is more charged with it than in winter. It is, however, well known that this humidity is more readily perceived in winter than in summer. This is accounted for by the fact that in winter time atmospheric air is as plentifully charged with these vapours as its low temperature will allow it to be, whereas this is far from being the case in summer time. During this last-mentioned period the prevailing heat would admit of atmospheric air imbibing a far greater quantity of vapour than it actually does; hence we have the feeling of drought in the summer time, but of humidity (wet) in winter.

The object of these watery vapours in the atmosphere is partly to destroy or free the air from other impurities, inasmuch as the latter become absorbed by the water, and so lose their noxious effect. The determination of the importance of these vapoury substances in the atmosphere has been developed by a separate science, called "hygrometry." It fulfils its task by determining the percentage of vapour contained in the atmosphere by means of suitable apparatus, the whole description of which would, however, carry us out of our present domain. Suffice it for the present to add hereto that with the aid of these instruments the humidity of the atmosphere has been found to increase gradually from sunrise. As soon as the earth has acquired a certain elevated temperature an upward current of air takes place which carries this humidity into the higher regions, thus causing the degree of humidity to become less in the lower atmosphere. Towards evening, when this air-current ceases, the degree of humidity in the lower atmosphere again increases, and this process continues until sunset. The dew then begins to fall—that is to say, the temperature has been so much reduced that a great portion of the vapour contained in the atmosphere can no longer exist as such. In winter time the effect of the sun's heat is not of so great an intensity as in summer. The humidity increases till two o'clock, and again decreases until sunrise.

It has already been remarked that oxygen becomes absorbed by water, though in very small quantity; but in many hot countries the water supply is so great that it has an important influence on the oxygen contained in the air. In fact, the atmosphere inhaled in such climes is somewhat poorer in oxygen, though not much. It is generally assumed that the amount of water contained in our atmosphere amounts to 0·84 per cent. The air of many districts, however, contains but little water, and so it is mentioned by Alexander von Humboldt and by G. Rose that in the Siberian steppes the temperature actually fell from 23·7° to —3° without causing the watery vapour to densify.

It is an astonishing fact that a decrease of humidity is almost exclusively observed the higher the elevation is. Even when dense fogs cover the summits of mountains and prevent distant objects from being seen this fact has been confirmed. The Swiss *savant* Saussure noticed that each time he ascended into the higher Alpine mountain region the top of his alpenstock fell off, which he attributed to the dryness of the higher surrounding air contracting the wood. Alexander von Humboldt made similar observations in climbing the South American mountains.

A further component part of our atmosphere is "ozone," discovered in 1840 by Schönbein. Owing, however, to limitation of space, we cannot enter into a dissertation on this interesting gas. Suffice it to say that it possesses a greater ability of combining with other easily decomposable bodies; that it readily destroys bad-smelling substances, and in this respect conduces to the general well-being of mankind.

There are a great many other bodies which may, either invariably or variably, be found in the air we breathe; so, for instance, we find ammonia, iodine, &c. &c. But such bodies present themselves in such minute quantities that to determine their actual existence we should have to go into millions of parts. Again, most of these bodies are either absorbed by watery vapours or destroyed by ozone.

In the preceding remarks we have only dwelt superficially on the question of quantities in describing the various properties of atmospheric air.

Every quantitative determination of a gas demands the reply to the two following questions:—

I. What amount of space is taken up by any gas in a certain space of the gas to be investigated? And,

II. What is the weight of any gas contained in the gas under investigation?

Evidently the first of these questions involves a determination of volume, whereas the second demands an analytical weight determination. Both of these problems may be solved by the quantitative proportions of the gases contained in our atmosphere.

Giving our attention to the first question, it has already been remarked, that Lavoisier found a decrease in volume when he heated quicksilver in an enclosed space. This decrease of volume amounted to about one-fifth of the whole, and this fact already gives us an approximate result of the voluminousness of our atmosphere; the determination of the other proportions still remains, but before proceeding with this special object we shall do well to describe an apparatus, which is based on a similar principle, and which enables us in a few minutes to complete the analysis of the air we breathe. Such an apparatus is presented to us in the "Eudiometer," an appliance which is exceedingly simple in construction, consisting merely of a graduated tube closed at the one end. The cubic capacity from one graduated

point to the next, remains constant in the tube. The eudiometer is filled with mercury, taking great care that no air-bubbles are formed in the tube, after which the air to be investigated is allowed to ascend in the tube. This operation is greatly simplified in cases where this apparatus can be applied on the spot, as, for instance, in an enclosed room. But the chemist is often obliged to investigate the air of different districts, and in such cases he goes to work in the following manner: Employing a glass retort whose neck comes almost to a point, this vessel is filled with boiled water freed of its air contents, sealed, and taken to the spot required. The vessel may be here opened, and as it empties itself the air to be investigated automatically takes the place of the displaced water. As soon as all the water has run out of this vessel, the bottle is hermetically sealed by melting its end. The chemist in possession of this intact vessel applies it to the eudiometer, and breaking its neck under mercury the air may be suitably collected into the tube of the apparatus.

Having now measured this quantity of air by means of the graduation, we know by qualitative analysis that a certain amount of carbonic acid is still contained therein. To measure the quantity of carbonic acid therein contained, we shall merely have to add a substance readily absorbing it into the tube, when the diminution of volume taking place must give the result in the quantity $C O_2$. By a similar process we may ascertain the amount of oxygen contained in the air under investigation, and then the remaining gas must be nitrogen. As a result to the experiments which have been made in this regard, it has been found that after the extraction of the carbonic acid in 100 volumes of atmospheric air, 20·9 volumes of oxygen and 79·1 volumes of nitrogen presented themselves, *i.e.* nearly in the proportion of 1 to 4.

The presence of watery vapour has, it is true, been ignored, but this may be determined by the quantitative method. The apparatus employed for this last determination is, however, rather complicated to explain without the use of a diagram; we shall, therefore, content ourselves with stating the results obtained by this *modus operandi*. After deducting the small amount of carbonic acid and watery vapours, it was found that 100 weight parts of air contained 23·1 weight parts of oxygen to 76·9 weight parts of nitrogen. Although the composition of atmospheric air has been so determined both on the mountain tops, in valleys, and on the sea, in short everywhere, different results in the proportion of these two gases have never been observed. This constant relation led to the supposition that the atmosphere was a chemical combination. The absorbent relations indicate, however, a mixture.

With the enormous consumption of oxygen, caused either through slow combustion, as in the respiratory process, or by actual burning of wood, coal, &c., the question whether the supply of oxygen is not likely to become exhausted is not altogether unreasonable. By means, however, of the before mentioned data as to the consumption of a grown-up man, it has been calculated that—supposing that ever since Adam's time one thousand million persons had been always living, the whole of the past and present generations would have only used up $\frac{1}{2\,0\,3}$rd part of the present oxygen supply. For the same number of persons this oxygen would still last 2,451,000 years. We may reckon that the square mile (German) of our earth's surface is able to produce over 2,600,000,000,000 lbs. of oxygen, and it is well to bear in mind that the earth's surface exceeds nine millions of these square miles. It is readily perceived that we find in these numbers amounts which scorn and hold our intellectual powers in defiance. In fact, we cannot gaze upon any of Nature's objects without feeling astounded at the providential and wise government to which all these objects are subjected.

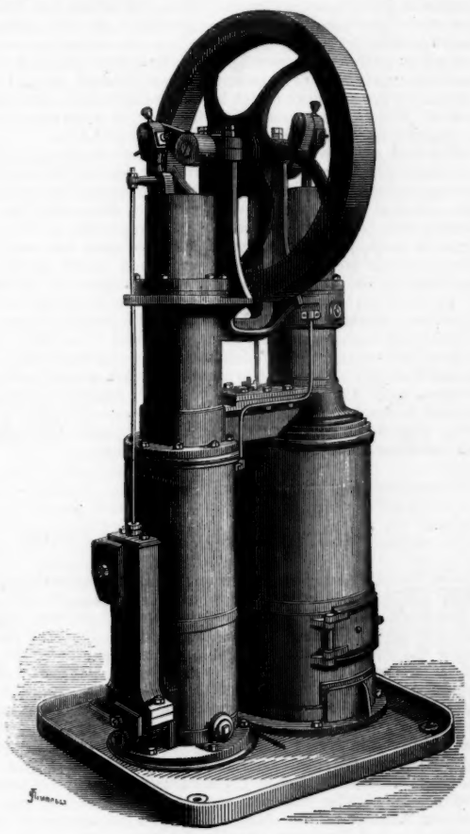
HOT-AIR ENGINE AT MESSRS. HAYWARD TYLER'S.

WE recently have had the pleasure of inspecting a hot-air engine at Messrs. Hayward Tyler's Works, Whitecross-street, London, which they exhibited at the Royal Agricultural Societies' Show at Birmingham, taking a silver medal for it. The engine is patented by Mr. A. K. Rider, of Walden, New York, and Messrs. Hayward Tyler are his English agents. The principle of this engine is to all intents the same as that so strenuously advocated by the late Captain Ericcson, though Mr. Rider has contrived means for overcoming a difficulty that operated greatly against Ericcson's machines—we allude to the rapid destruction of the packing by the heat, and the difficulty of lubrication.

Mr. Rider's engine consists of a small circular fire-box about 10 in. diameter. The top of this box consists of a cast-iron flange with a cylindrical central portion projecting downwards into the heated space in the furnace; the centre of the bottom of this cylinder is cupped upwards so as to catch as much of the heat as possible, the cylinder is continued some distance above the flange and is called the "power" cylinder; and secured within it is a somewhat smaller cylindrical chamber of very thin metal; this passes almost to the bottom of the power cylinder, and serves to conduct the air into as close contact as possible with the heated lower part of the power cylinder.

A trunk plunger works in this cylinder and passes through a packing of a pair of cup leather rings of somewhat peculiar construction, so arranged in the cylinder cover that the leather is never exposed to any heat save that of the trunk rubbing past it.

Alongside, though at a little distance, is another cylinder,



HOT-AIR ENGINE.

called the compression cylinder; the lower portion of this also is lined with a thin interior tube, a narrow annular space existing between the outer surface of the liner and the bore of the compression cylinder; through this annular space a circulation of cold water is maintained to cool the air. A trunk plunger similar to that described above is fitted here also, and the cylinder cover packed with cup leathers. The two cylinders—power and compression—are united above by a horizontal chamber divided into narrow passages by a series of very thin partitions; this is called the regenerator. Above this is a pair of standards which carry a shaft and fly-wheel and either end of the shaft is a crank, connected by a rod in the usual way to the trunks. The power crank is set at an angle of from 85° to 98° in advance of the compression crank, their exact positions relatively depending on the amount of clearance in the passages, &c.

The action of the machine is briefly as follows: The compression plunger first compresses the cold air in its cylinder or chamber into about one-third of its natural volume; when, by the upward motion of the power plunger and the completion of the downward stroke of the compression plunger, the air is transferred through the regenerator into the heater or lower

part of the power cylinder, without much change of volume, the air being raised suddenly to a high temperature here, it gets a correspondingly great expansive force and forces the power plunger upwards to the end of its stroke; the expansive force now acts in turn on the compression plunger, which is also now commencing its ascent, and forces it nearly to the top of its stroke. Before this is completed, however, the cold compression cylinder and regenerator through which the air has passed cools down the air, which loses its force, and the compression plunger begins the operation of compressing over again; the heat given up to the regenerator by the hot air is now picked up again by the colder air returning to the heater, and so the operation goes on. The circulation of water round the compression cylinder is effected either by the main pump worked by the machine, or else a little one may be specially provided.

The objection to hot-air machines is their great bulk in proportion to the power they exert. Thus, the machine at Messrs. Hayward Tyler's has plungers, or pistons as the patentee erroneously calls them, 6¾ in. diameter, the stroke of the compressor being 8 in. and of the power 8¾ in. It has been pumping water equivalent to a head of from 60 to 90 ft. at the rate of 650 to 700 gallons per hour, a duty of not half an indicated effective horse-power. The consumption of fuel, however, is small for so small an engine—21 lbs. of coke running it for seven hours.

The real value of this machine is its perfect safety, and this advantage will operate largely in its favour, for the simple reason that a good domestic motor, if we may so apply the term, is a great want at the present time—a motor of from a half to two-horse power. At a large number of establishments, such as gentlemen's seats, hotels, jobmasters, small farmers, and others, a variety of operations have to be performed nearly every day, too small for the profitable introduction of steam and yet which a motor could do better and cheaper than manual labour. Moreover, a steam-boiler, however small, needs a specially trained and highly paid attendant, and even then there is an element of danger present, felt so sensibly by insurance companies that they charge extra premiums when steam-power, on however small a scale, is used. The hot-air engine we have just noticed is absolutely safe and needs no special skill on the part of its attendant, consequently these advantages outweigh its drawbacks and commend it to public attention.

THE MINERAL RESOURCES OF SPAIN.

THERE has just been published, by order of the Government, the mineral statistics of Spain for 1872. Apology is made that "political vicissitudes, and as their consequence, repeated change in the executive, led to great disorder in the Department of Mines; the Carlist occupation of the principal mineral provinces added considerably to this disorder, in making the collection and verification of returns impossible." It is hoped, however, that the reports for 1873 and 1874 will follow promptly on the present publication. In 1872, 41,033 men, 2,014 women, and 7,040 boys were employed in Spanish mines. Iron was worked in 1872 in 371 mines, distributed over twenty-one provinces; the principal seats of production of iron ore were in Biscay, Murcia, Almeria, Oviedo, Santander, Malaga, Guipuzcoa, and Navarre. Coal in the same year was in course of extraction from 228 pits, employing 5,158 men, 545 women, and 607 boys. Oviedo was the province in which most coal was raised. An eloquent appeal is made in the "Fomento de la Produccion nacional" for a new impulse to the mining industry in Spain, which, as is very well argued, has no mineral riches until she can convert her ores into metal. The writer beseeches the Government to "increase the number of mining engineers, and, above all, to build coal railways. Private enterprise cannot be at fault. If it depended on this only there would be no further difficulty to conquer, for we have known a mine owner rather smelt his lead with esparto roots than not work it at all, which was his other alternative." The appeal, eloquent as it is, shows how low in Spain is the trust in oneself and each other, which in this country does more for us than we wish Government even to attempt on our behalf. The writer estimates that there are 12,120,000,000 tons of coal to be extracted, distributed in the following provinces:—Oviedo, 2,000,000,000 tons; Burgos y Soria, 600,000,000; Leon y Palencia, 1,000,000,000; Catalonia, 500,000,000; Santander, 100,000,000; Cordova, 300,000,000; Cuenca, 20,000,000; Teruel, 7,000,000,000 tons. Lignite, too, is present in several provinces. With such abundance of fuel and ore, Spain has to buy her railway plant, her arms, her cooking utensils, from the foreigner to whom she sends her raw material.

HYDRAULIC FORGING.

AT the recent meeting of the Iron and Steel Institute the following instructive and important paper was read on "the hydraulic forging and stamping of malleable iron on the système Haswell of Vienna," by Mr. J. O. Butler, of Kirkstall Forge, who referred to diagrams on the wall illustrating this paper:—

The forging and shaping of malleable iron has been practised from the earliest period. Long before the Christian era, it is recorded that there were "cunning workers in iron," rude in shape at first, no doubt, and with appliances of the simplest character. As time rolled on, however, and civilization advanced, and men's wants multiplied, refinements in the mode of working produced superior "handicrafters;" and, approaching our own times, we have sufficient evidence of this in our armouries, museums, and arsenals, where are found, in all parts of the world, magnificent specimens of workings in iron, chiefly, however, for warlike purposes. Coming nearer to our own times, and, we may say, to the commencement of the present century, or even so recently as forty years ago, the manipulation of malleable iron, when in an incandescent state, into shapes of almost endless variety, has been greatly stimulated by the ever-varying requirements of the practical engineer. The introduction of steam into our mercantile marine and into our navy, as well as the locomotive engine, which was the natural offspring of our railways, has called forth the inventive genius of our workers in iron in a most remarkable manner, and perhaps no machine has brought out the talents of our working smiths more than the locomotive engine. The writer well remembers the time when smithwork, even of a comparatively simple kind, was difficult to be executed, and it was often the case that the designer and the draughtsman had first to chalk out the piece of work he wished to be done, in a particular fashion, on the fore-plate of his smith's hearth, and ask his workman, "Can it be done like this?" when he would often reply, "No, maister, it cannot be done!" We must not, however, omit here to mention that the rapid strides made in the operations to which allusion has been made, are due almost entirely to the steam-hammer—that wonderful production of the brain of a Nasmyth, which, about thirty-five years ago, revolutionized the operations in our forges and smiths' shops. In the present day, masses of iron of immense magnitude are being manipulated with ease that once were thought impossible—witness our "Woolwich Infants" and other kindred pieces, such as armour-plates and the like, which have first to go under the steam-hammer. The pressing of iron into a mould, or matrix, to give shape to various articles by the aid of the screw press, has also been practised for many years; the steam-hammer has likewise been brought into requisition for the same purpose, but to a limited extent only. Reciprocating blows from a steam-hammer, it is found, do not produce or accomplish, satisfactorily, the kind of pressure necessary for forcing the atoms, or molecules of iron, in an incandescent state, into all the interstices of a mould where intricacy and accuracy are desired. This, however, can be done effectually by the inexorable thrust of a hydraulic or hydrostatic "squeeze." And this leads us to the subject of the paper now before you. We believe that Mr. Haswell, of Vienna, was the first to bring into practical and useful operation the "squeezing" of malleable iron at a welding heat into shapes and uses, as they are technically called, previous to their being manipulated by the smith and fitter. Some years before Mr. Haswell's patent of the machine, or tool, now under consideration was designed, hydraulic power had been made use of for forging or pressing malleable iron, both with and without the aid of an accumulator; but it is to Mr. Haswell that we are indebted for the improvements which make the hydraulic press a tool of general use. The drawings or photographs against the wall illustrate the machine or tool that he has produced for that purpose. It will be perceived that it is simply the adaptation of the hydraulic press, on the principle of Bramah, with an arrangement peculiar to Haswell, whereby a "squeeze" can be given, either reciprocating or in one continuous thrust, until the piece operated upon acquires the desired shape.

The pumps are worked by a horizontal direct-acting steam cylinder of large size, the working of which is directed by an automatical arrangement, so that it is perfectly and instantaneously under the control of the driver.

The press consists mainly of two vertical cylinders of different sizes, which are fixed to a large cast-iron frame of cruciform shape, and may be termed the *pressing* and *lifting* cylinders respectively, the one below and the other above. The frame is supported on four malleable iron columns or pillars, which are

firmly secured to a bed plate of a shape corresponding to the frame.

The two pistons, or rams, have cross heads fitted on their outer ends, connected at their extremities by two strong malleable iron side rods, so that the pistons, or rams, work simultaneously. These rods, passing through grooves formed in the upper frame and the intermediate steadying frame, act likewise as guides to prevent the rams turning. The hammer, or upper mould, or matrix, is, of course, fixed or fitted to the lower end of the pressing ram, and the bottom anvil, or mould, or matrix, is firmly bedded to the bottom bed plate. The main steam cylinder is fixed horizontally on a strong bed plate, the piston rod passing through packed stuffing boxes at both ends, to which are attached, in the same line and plane, the rams of the respective hydraulic pumps. A small steam cylinder is placed by the side of the main steam cylinder to work its slide valve. Attached by a lever to the valve rod of this small steam cylinder, is a tappet rod, which is worked automatically by a projecting arm attached to the cross head of the pump ram, this acting upon the slide valve of the small cylinder, which, in its turn, actuates the slide valve of the main cylinder which works the pumps. The discharge branches of the two pumps are connected by pipes with passages and chambers. The inlet and discharge regulating valves are worked by strong levers having rods attached to their free ends, and directly connected with the piston rods of two small auxiliary steam cylinders. The slide valves of these auxiliary cylinders are respectively worked and controlled by means of hand levers. The small cylinders, which we may term cushion cylinders, are charged with oil and have perforated pistons, the rods of which are also connected to the regulating valve levers before named. These cylinders act as cataracts, or buffers, to relieve the sudden "chuck" incident to the work put upon the levers. There is also a loaded safety valve, placed in a convenient position on the pressure pipe, for relief in case of need. The press may be worked at any desired pressure, regulated by the boiler steam pressure; and either a light or heavy blow, or squeeze, can be given to suit the work in hand. The velocity, or number of strokes per minute, depends upon the efficient action and rapidity with which the two auxiliary cylinders can be worked, as these regulate the inlet and escape valves, the driver having merely to handle the levers of the slide valves. It will be perceived that no expensive foundations are required, as both the engine and press are self-contained.

The discussion which followed was of an eminently practical character, and was participated in by most of the manufacturers present. Mr. Price Williams said that the Haswell press was the exact carrying out of Tresca's theory of the flow of solids. Mr. Carbutt, speaking as a manufacturer of steam-hammers, thought that although they would not be quite superseded by the Haswell machine, they would be less used in the future; he also remarked that, from his practical experience with one of the presses the dies were expensive, as they absorbed the heat from the metal. Mr. Paget having also had personal experience of the hydraulic press, said that, strictly speaking, it was not forging that was done by it, but rather swaging; and that it can only be used to pecuniary advantage in work in which there is repetition. In such cases the saving is very great, amounting, for such uses as locomotive cranks, to fifty and even more per cent. as compared to forging under the hammer. The most efficient way of using the Haswell press would be to set it up in connection with puddling furnaces. After some remarks as to the comparative economy, &c. of the hydraulic press and steam-hammer, Sir Joseph Whitworth was called upon. He said the great novelty in his application of hydraulic power was in giving intense pressure to the fluid metal. On applying this great pressure to a column of metal its length was diminished one-eighth in less than five minutes. This would indicate to them the amount of work done, and the effect with which the air-cells were expelled. It had been a somewhat dangerous and difficult process to carry out, but it was now quite successful, and his firm were preparing to carry it out on a much larger scale. It might be of interest to mention that they had lately completed for Her Majesty's ship "Inflexible" two twin screws, 283 ft. in length, weighing 63 tons. The weight of iron would have been 97 tons, so that by using this compressed steel they saved 34 on the driving round of two shafts during the whole life of the engine. These shafts were now lying at the yard of Messrs. John Elder and Co., Glasgow. The strength of the shafts was 40 tons to the square inch, and their ductility or power of extension was 30 per cent. of their length; they were 17 in. in diameter, and had a 9-in. hole through them. It was found desirable to get the pressure applied as soon as possible—when, in fact, the metal was still at a white heat. The firm had not applied the process for forging iron, what they had done having being done entirely with fluid-compressed steel. The value of the hydraulic pressure in forging, so far as his experience went, was in proportion to the size of the mass; the larger it was, the better the hydraulic pressure. In reply to a question, Sir Joseph added that the value of the fluid compression was in proportion to the ductility of the metal. If they wanted to produce a steel that would have 30 per cent. of ductility, they could not produce it at all without pressure; otherwise it would be full of air-cells. The fact that gas was squeezed out of the cells was proved by the fact that there was a considerable flame burning from them during the process, owing to the escape of the gas.

Mr. Butler, in reply, said that the pressure on the cylinder depended on the steam; with a diameter of 24½ in., about 2 tons to the square inch, or a pressure of 11,000 tons, was required to force the iron into the die with one squeeze lasting 1½ minute. The axle box exhibited had been produced in six minutes after leaving the furnace. The hydraulic press was used not so much for welding as for swaging. The press would do what the hammer would do, and *vice versâ;* the former required comparatively small foundations. When he saw the iron being forced, like butter, into every corner of the mould by the Haswell press in Vienna, he saw it was a splendid tool, and therefore took it up. On Mr. Butler observing that the 10-ton cast-steel cylinder for the press could not be obtained in England, but had to be imported from Bochum, in Westphalia, an animated conversation ensued, which was closed by the President saying he thought Mr. Butler had failed to establish that the cylinder in question could not have been produced in England ten years ago.

NICKEL AND ITS PREPARATION.

NICKEL is not an abundant metal; and although it occurs in a dozen different ores, the number of localities where it is found in paying quantities is very few. It is never found in a metallic state, except in meteorites. In ores, it is generally associated with iron and cobalt, both of which it resembles. The principal source of nickel is the native arsenide, a copper-coloured mineral, called by the Germans *kupfer-nickel*, or false copper, because it contains no copper. This ore contains from 33 to 55 per cent. of arsenic, 33 to 45 per cent. of nickel, and small quantities of sulphur, iron, and other substances. Another compound of nickel and arsenic has received the name of cloanthite or white nickel. Annabergite, or nickel bloom, is a compound of arsenic acid with oxide of nickel, quite soft and of an apple-green colour. The most beautiful nickel mineral is the sulphide, or millerite. It has a brass-yellow colour and metallic lustre, and usually occurs in capillary crystals, in the cavities and among the crystals of other minerals, hence called capillary pyrites. In America it is found chiefly in Lancaster County, Pa. The other nickel minerals are breithauptite, nickel glance, ullmanite, emerald nickel, pyromelin, grunanite, pimelite, garnierite, and noumeite. Speiss is a deposit formed in the pots in which roasted arsenide of cobalt, mixed with copper nickel, is fused with carbonate of potassium and quartz, for the preparation of smalt in the blue colour works; it collects below the blue glass in the form of a metallic alloy, the nickel not oxidizing so easily in roasting as the cobalt. It is an important source of nickel.

Of the metallurgy of nickel little is known outside of the works, which are carefully guarded, although it is difficult to see of what use a knowledge of a process could be to those who have no source of material at hand, or why those who have a monopoly of the ore need fear competition. Professor C. Küntzel has, however, published some interesting facts in regard to the method used in the metallurgy of nickel, from which we glean the following:—

The preparation of metallic nickel and cobalt is sometimes conducted in the dry way, by collecting and concentrating the nickel, cobalt, and copper, in an arsenical or sulphur compound (*speise* or stone), while, at the same time, the iron in the ores is removed by scorification; the cobalt is afterwards fluxed with pure quartz sand, and the protoxide of cobalt precipitated from the silicate of cobalt thus formed by fusion with excess of carbonate of soda; the sulphur or arsenic is expelled from the *speise*, which has had the cobalt removed by roasting and heating with soda and saltpetre, and finally reduced with carbon. It is more frequently obtained in the wet way, by dissolving the nickel and cobalt ores in acids and separating the dissolved metals, but the greater part of the iron should first be removed and the nickel and cobalt concentrated before dissolving. In the dry method the first step is also to get rid of the iron in the

ore or *speise*. The complete separation of iron from arsenical compounds of nickel and cobalt is not very difficult, for iron has much less affinity for arsenic than cobalt or nickel; but to separate it from the sulphides was, until recently, very difficult, if not impossible. The reason of this is, that nickel and cobalt have nearly the same affinity for sulphur that iron has. This operation is now accomplished by smelting the raw ferruginous ore in a reverberatory furnace with a mixture of two parts of fine barytes and one part quartz sand; for 1 per cent. of iron, 18 to 19 per cent. of this flux is required. A fusible ferro-silicate of barium is formed and sulphurous acid driven out. In 1870 Dr. R. Wagner proposed to make use of the oxidising action of Chili saltpetre for removing the iron, sulphur, and arsenic. For arsenical products, this method is inferior to the one generally employed, namely, roasting the metallic arsenides after the iron has been removed, then heating with saltpetre and soda. Wagner's method may be employed with advantage when it is desired to smelt a nickel ore which has been freed from iron with a metal free from sulphur, provided it contains enough copper to prevent the resulting metal from being too infusible.

The manufacture of nickel in the wet way varies with the material or source. The principal steps are the following :— 1. Dissolving the roasted products in hydrochloric or sulphuric acids. 2. Precipitation of the iron by means of lime, or carbonate of lime, or soda, after oxidising, if necessary, with chlorine or chloride of lime. 3. Precipitation of the copper with sulphuretted hydrogen or alkaline sulphides. 4. Precipitation of the cobalt as sesquioxide by means of chloride of lime. 5. Precipitation of the nickel as hydrated oxide or carbonate with milk of lime or carbonate of soda. 6. Igniting this precipitate so as to obtain anhydrous oxide of nickel insoluble in dilute acids. 7. Leaching out the excess of lime and gypsum from the ignited oxide of nickel. 8. Reduction of the pure oxide of nickel by ignition with charcoal.

In dissolving nickel ore, care should be taken to prevent silica going into the nickel solution, for, on neutralizing the previously acid solution, all the silica is precipitated in the form of silicate of nickel. Sometimes in analyses a small quantity of silicic acid runs through all the operations, and there is no simpler method of removing it entirely at the start than by adding to the neutral solution some neutral nickel salt.

For precipitating the copper with sulphuretted hydrogen, Gerstenhoefer's precipitating tower, which was first employed at Freiburg to precipitate arsenic from sulphuric acid, may be employed. Such an apparatus avoids any escape of the gas, and precipitates the metals in the shortest possible time. The solution enters automatically at the top of the tower, which has an hydraulic seal. It falls, drop by drop, down into an atmosphere of sulphuretted hydrogen, passing from one platform to another; and if it does not contain too much copper it passes out at the bottom free from copper. The gas which is absorbed by the nickel solution is expelled by heating it with steam. If a soda ash works is near, the waste sulphide of calcium may be employed with profit for precipitating the copper. Injury to the workmen from inhaling sulphuretted hydrogen can be prevented by the use of wine or spirits; sulphuretted hydrogen retards the circulation of the blood, which is neutralized by the property that alcohol has of accelerating the circulation.

Nitrate of potash cannot be employed to separate nickel and cobalt when there is lime in the solution. In this case it cannot even be used as a test; for in the presence of lime or other alkaline earth, a yellow precipitate is formed, similar to the nitrite of cobalt and potash, and is said to have the composition $K^2\,Ca\,Ni\,(NO^2)^6$. If there is enough lime present, all the nickel is thrown down as a double nitrite.

Cobalt and nickel may be separated by means of sulphate of ammonia and sulphuric acid if the quantity of cobalt is not too small relatively. The separation is quite exact if the solution is sufficiently concentrated. The nickel separates as a difficultly soluble double sulphate of nickel and ammonia, while the double salt of cobalt remains in solution. From the former the sulphate of ammonia is expelled by heating in clay pipes. The sulphate of nickel is almost entirely converted into oxide by roasting with charcoal; the last trace of sulphur is removed by igniting with soda and saltpetre.

The best method of removing the sulphate of lime is to extract the excess of lime added with hydrochloric acid water, then to boil the oxide with steam, and add slowly such a quantity of carbonate of soda that after boiling a quarter of an hour there is still an excess of the carbonate in the solution. Sulphate of soda and carbonate of lime are formed; the first is washed out with water, and the latter with water acidified with hydrochloric acid.

Oxide of nickel can be reduced at a bright red heat by simple contact with coarse broken charcoal. The reduction extends inwardly from the surface of the cubes. If left in contact with the carbon after it is entirely reduced, it absorbs more and more carbon. The reduction usually takes place on the clay crucibles on the hearth of a flame furnace. At Val Benoit, near Lüttich, a continuously working furnace is used, the reduction being accomplished in upright tubes. *Scientific American.*

ZINC AS A PREVENTIVE OF BOILER INCRUSTATION.

THE use of zinc as a means of preventing boiler incrustation is notoriously of quite recent date. It is, therefore, not to be wondered at that the means towards obtaining success in its adoption have not yet been clearly shown. The following trial, published by O. Krug in the "Zeitschrift für Paraffin, &c., Industrie," proves that, with this application of zinc, the quality of water has no influence whatever, and that the only difficulty which remains is to find the right way of applying it to have the safest and cheapest means of getting rid of incrustations. For trial of the application a double boiler was selected; in each of the boilers three bars of cast zinc were horizontally laid, at about equal distances from each other, having their ends cut so that they fitted to the sides of the boiler, and centrally 200 millimetres (13·86 in.) distant from the lower part of the boiler. The bars had a square cross-cut of about 35 millimetres (1·375 in.), and the six altogether weighed 44·5 kilos. (98·02 lbs.). Upon the bars were also strips of zinc weighing together about 2 kilos. (4·40 lbs.), which were squeezed between the ends of the zinc bars and the sides of the boiler. On the 20th April of the present year the fire was lighted under the boiler, and put out on June 11th, after working about seven weeks. It was found as follows :—

There was no trace of incrustation, whilst water, without the application of zinc, used during the same lapse of time, deposited a layer from 2 to 4 millimetres (0·078 in. to 0·156 in.) thick. In the lower boiler was an abundant deposit of mud—less in the upper boiler. The zinc bars had completely disappeared in the lower boiler. Small corroded pieces of the strips were found on the sides, the remainder were protected against further corrosion by a thick adhering crust of mud.

In the upper boiler the strips were to be found, as in the lower boiler, only in separate parts, embedded in the mud. The zinc bars, on the contrary, had moved but little from their places; but they were no longer free at their ends, they rested on the walls of the boiler, having sunk and taken the form of the boiler. Moreover, they had completely lost their metallic nature, and had been transformed into a mineral mass resembling very solid clay. The volume had considerably increased, so that the square cross-cut was about 55 millimetres (2·145 in.) on each side, the whole mass being quite brittle. This explains the disappearance of the bars in the lower boiler: they had been so far corroded that they melted in the mud.

To get in some measure a safe basis from which to judge this remarkable phenomenon, a correct analysis of the body to which the zinc had been transformed, as well as of the remaining water and of the mud, appeared necessary. Beginning with the analysis of the remains of zinc, worked out by Dr. Drenkmann, it gave the following results :—

1.	Moisture	0·55 per cent.
2.	Organic substance and carbon	0·22 „
3.	Mud and silicic acid	0·67 „
4.	Gypsum	4·37 „
5.	Hydrochlorate of soda	0·12 „
6.	Carbonated chalk	0·25 „
7.	Sulphur	0·02 „
8.	Lead	0·90 „
9.	Antimony	a trace.
10.	Tin	a trace.
11.	Iron	0·80 per cent.
12.	Metallic zinc	2·30 „
13.	Oxide of zinc	88·70 „

The substances above enumerated, from 1 to 6, are undoubtedly supplied by the water, whilst the remainder, from 7 to 13, come from the rough zinc used, only increased by the oxygenation.

It is to be seen from the list of the less important matters, that the product of the transformation of the zinc has been oxide of zinc (without hydrated water). Hence one may, without doubt, infer in what manner the process in question is to be explained.

The iron of the boiler's sides forms with the zinc bars a galvanic action, through which the water is decomposed. On the whole boiler's sides, so far as they are touched by the water, hydrogen

is disengaged during the whole operation, whilst oxygen attacks the zinc, oxidising it, at the same time. The constant separation of the gas-bubbles on the inner sides of the boiler, prevents the sticking of the incrustation of carbonated chalk, which can only separate as mud. The composition of the water is therefore indifferent. The decomposition of the water, and thereby the prevention of the incrustation of the boiler, will occur, whatever may be the composition of the water. The influence which the impurities of the water might exert upon its effective power, might be considered as disappearing. The iron cannot be attacked on the outside by this process; on the contrary, the oxyhydrate of iron existing is reduced. Until now we have no means to judge if the constant electric tension has any influence on the structural proportions of the iron plate. The almost complete dissolution of the zinc, except 2·30 per cent., is remarkable. One would have supposed that the effective power of the zinc bars ceased sooner. That by the use of zinc strips, and also of zinc blocks, which were found at the bottom, but were protected from coming in direct contact with the metallic iron by the mud and the carbonated chalk coating, imperfect results only were obtained, is also clearly explained by that which precedes.

The quantity of zinc employed in this case is rather considerable. It remains to be found, by new trials, to what minimum the use of zinc may safely be reduced. *Stummer's Ingenieur, Sept.* 1876.

CITRATE OF IRON AND QUININE.

AT the meeting of the British Pharmaceutical Conference, on Sept. 6, a paper on a "Proposed Solution of Citrate of Iron and Quinine," by J. F. Brown, was read. He said: Just two years ago I was led to consider the possibility of preparing at home the citrate of iron and quinine. To this course there were two strong inducements—its importance, and the difficulty of testing its quality. Quite recently the latter has been materially lessened by the published researches of Messrs. Allen, Palmer, and Cownley; but at that time manufacturers were more eager to proclaim that their preparation fulfilled the official tests than practised in the art of applying them.

One eminent firm wrote me that "The B. P. instructions, even when very carefully followed, generally give different results, although the samples be taken from the same bottle and worked under precisely the same circumstances."

At the outset I abandoned any idea of scaling the salt, as beyond the scope of my time or appliances, and taking, on Mr. Umney's authority (see "Pharmaceutical Journal," August 30, 1873), four and a-half ounces as the yield of the quantities ordered to be used, I so far modified the formula as to obtain a solution containing five grains in each fluid drachm.

As preservatives I tried first sugar and glycerine, and found both answer very well, the only perceptible difference being that the solution with glycerine changed from the reddish-brown colour, common to both when fresh made, to a much more pronounced green colour than did the syrup.

I use now chloroform in the proportion necessary to convert the solution into aqua chloroformi, and find it unexceptionable, preserving it quite clear and bright for months, and serving also to render it more palatable.

The precipitated quinine should not be suffered to dry upon the filter after washing; nor should it be added to the solution of citrate of iron until the latter has cooled, or it will fuse into soft, tenacious lumps, which dissolve very slowly.

The addition of the ammonia according to the Pharmacopœia process is a tedious operation, involving a good deal of labour; but by diluting it to rather more than the volume of the citrate solution, and mixing in a large bottle, with brisk shaking, the combination is very speedily effected, the separation of the quinine being scarcely visible, so rapidly is it re-dissolved.

The only modifications of the official directions which I propose in order to adapt them to the solution are these:—Dilute 12 fluid drachms of solution of ammonia with 25 fluid ounces of distilled water, and add to the cooled solution contained in a stoppered half-gallon bottle, agitating briskly; filter, make up the measure to 49 fluid ounces with distilled water, and add two fluid drachms of pure chloroform; shake briskly at intervals for 24 hours. Each fluid drachm contains five grains of the citrate.

I have tested the solution so made both by the Pharmacopœia process, and by agitating twice with ammonia and ether, pipetting off the latter and evaporating in a tarred watch-glass. The results were not satisfactory: 14·9 per cent. of quinine by the former, and 15 per cent. by the latter process. But I believe that this deficiency arose either from my inexperienced manipulation or from faults in the methods employed, as the results compare favourably with those obtained by testing, under similar conditions, the usual scaled product.

A speculation on the chemical constitution of this salt is perhaps scarcely worth attention, but I may note in conclusion that—

3·00 oz. citric acid,
·70 oz. anhydrous quinine,
·14 oz. ammonia gas, and
·66 oz. metallic iron,

contribute to the 4·5 oz. obtained; and these quantities correspond nearly to the formula:—

$$(C_{20}H_{24}N_2O_2)_3, 2\,C_6H_3O_7, Fe'''C_6H_6O_7, NH_4H_2C_6H_5O_7,$$

also that it contains 22·7 per cent. (nearly) of citrate of quinine.

Chemistry applied to the Arts, Manufactures, &c.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

SALICYLIC Acid.—Professor CH. BLAS has just published a summary of researches, made by various German scholars, about salicylic acid, in which he establishes that this acid, the formula of which is $C^7\,H^6\,O^3 = (C^6\,H^4)\,OH, CO^2\,H$, is very useful in medicine, pharmacy, domestic hygiene, and industry, above all, in the various branches which bear on organic matters; and is to find a place with bromuret of potassium, chloral, and phenic acid, among the most important medicines with which chemistry has enriched therapeutics for many years past.

In the International Congress of Medical Science at Brussels, M. Vandevyvere exhibited blood preserved by means of salicylic acid for four months, which possessed all the characters of fresh blood. M. Vandevyvere proved likewise the influence of this acid on the tainted water of a well and upon the organic bodies which move in it. *Porvenir de la Industria, Oct.* 6, 1876.

Preservation of Blood from Slaughter-houses.—Fresh blood from slaughter-houses is preserved by the addition to it of from two to five per cent. of quick or slaked lime, in a pulverulent state or in small pieces. The chalk is precipitated in the blood and a jelly is formed. This jelly is simply dried in the sun, or an oven, if wanted to be preserved for long time. If it is to be immediately used, or within the following fortnight, it is mixed with flour of inferior quality, or with any alimentary substance, in the form of a dry powder. *Plata Industrial, Aug.* 10, 1876.

The Cattle Plague.—M. AMEDÉE PHILIBER, a Russian grazier on an extensive scale, affirms that above all the means used to preserve horned cattle from the cattle plague the best is the distribution of sea-water, instead of sweet water, to the animals during the epidemic. *Rivista Scientifico Industriale, Aug.* 1876.

Cheap Washing.—A new system of washing has lately been introduced in some French towns, which system deserves to be especially mentioned. The economy which it affords is so considerable that its cost is reduced to the following figures:—5 centimes ($\frac{1}{2}d.$) for a pair of drawers, $2\frac{1}{2}$ centimes ($\frac{1}{4}d.$) for each shirt, and so on.

This is the process: One kilo (2 lb.) of soap is reduced with a little water to a sort of pap, which having been slightly warmed, is cooled in forty-five litres (10 gallons) of water, to which is added one spoonful of turpentine oil and two spoonfuls of ammonia; then the mixture is agitated. The water is kept at a temperature which may be borne by the hand. In this solution are introduced the white clothes, and they are left there two hours before washing them in soap, taking care in the meanwhile to cover the tub. The soapy water may be warmed again and be used once more, but it will be necessary to add half a spoonful of turpentine and another spoonful of ammonia. Once

washed in soap, the clothes are put in warm water and the blue is applied. This process, it is obvious, spares much time, much labour, and fuel. On the other hand, it gives to the clothes a whiteness much superior to that obtained by any other method, and the destructive use of the beetle is not necessary to clean the clothes from the impurities which they contain. *Gaçeta Industrial, Sept.* 25, 1876.

Easy Means to ascertain the presence of a Bicarbonate in Solution (by Piria).—Some experiments by MÉHU show that bicarbonates precipitate sulphuret of mercury dissolved in sulphuret of alkalinised soda, with potash and caustic soda, which does not happen with the solutions of carbonate. When it is desirable to distinguish the solution of a carbonate from that of a bicarbonate, it is sufficient to dissolve sulphuret of mercury, black or red, in a solution of sulphuret of sodium and caustic soda, rather in excess, to filtrate the dissolution, and to mix it with the solution of carbonate or bicarbonate. In the last case there will be a precipitate of amorphous sulphuret of mercury.

For the success of this experiment, it is necessary that the sulphuret of soda be not adulterated with polysulphur. *Rivista Scientifico Industriale, July*, 1876.

Use of Petroleum to Facilitate Metal-working.—The application of petroleum as greasing material in turning on the lathe very hard metals is of great advantage, since cutting-tools continually wetted with petroleum may easily attack and work the hardest sorts of steel, which it would be almost impossible to work without the application of this means. It has been shown that a very hard alloy of 7 parts of zinc, 4 parts of copper, and one part of tin, which even with the best hardened chisel could not be worked, could be turned with the greatest ease on a lathe, if the tool is moistened with petroleum. With the now more and more frequent use of steel this discovery is of no mean importance. *Stummer's Ingenieur, Sept.* 1876.

A New Adhesive.—An adhesive which, so far as colour and durability are concerned, is affirmed to surpass that made from gum arabic, is made according to the following recipe, viz.:—Milk is curdled by the addition of acetic acid (vinegar), and the precipitated casein, after being thoroughly washed with fresh water, is dissolved in a cold, saturated, solution of borax. The result is a clear solution of syrupy consistence, possessing upon drying a fine lustre and high adhesive qualities. This adhesive is recommended for a variety of uses. *Beiblatt zum Phœnix, Sept.* 2, 1876.

A New Use for Sea Weed.—Hai-thao, or gelose, is a tasteless, odourless, colourless mass, obtained from a fibrous seaweed, common on the coasts of China and Mauritius. It is insoluble in cold water, but dissolves in hot water, after boiling for ten minutes, and then forms a thin, dirty, white solution, which, on cooling, deposits a yellowish grey jelly. The material has lately been used for finishing cotton fabrics, and is reported to fill the thread more perfectly than dextrine or starch. By adding glycerine to the hai-thao solution, a still softer, and at the same time stronger material is obtained. According to experiments made by HEILMANN, an abstract of which is given in Dingler's "Polytechnisches Journal," it appears that the material can only be employed for fine textures, soft and firm to the touch, and cannot be used as a substitute for dextrine or potato starch where a strong material is required.

The Manufacture of Dynamite.—The explosions which take place in manufactories of dynamite are probably caused, according to M. SOBRERO, in the preparation of the paste of nitro-glycerine and the absorbing material, or in the moulding of this paste, by compression, in giving it the form of cartridges. Compression and friction against hard substances are in reality frequently the causes of explosions of nitro-glycerine. In order to avoid this danger, M. Sobrero proposes to greatly modify the manufacture of dynamite, by forming the silicious materials of the nature of Kieselguhr, after they have been wetted a little with water, into cartridges, such as are to be employed, and to dry them to 100 degrees Cent. to expel the water. The lumps thus obtained, preserving the state of aggregation given them, are more absorbent than the materials of which they are formed. It remains thus only to introduce the explosive matter, which is easily done by dipping them vertically in the liquid which it is intended to introduce. One can thus obtain dynamite containing 75 per cent. of explosive matter, a form usually required. In proceeding thus, every violent action of pressure or friction is avoided; the lumps as they leave the bath of nitro-glycerine need only be placed in a convenient place for letting the excess of the liquid run off, and they are then quite ready for being put into paper parchment and for sale. *Le Technologiste.*

The Extraction of Iodine and Bromine.—A new process for extracting the iodine and bromine contained in wrack and other marine plants, in their fresh state, is recommended by E. P. ALEXANDER in the "Technologiste." He dispenses with all preliminary processes, chemical or mechanical, and, amongst others, with burning them, simply submitting the wrack, &c., to the action of lime-water of a fixed strength and quality. The iodine contained in those plants passes into the lime-water, which, thus charged with iodine, is evaporated to dryness by the usual means, after having been treated with a solution of carbonate of potassium, changing all the iodine and bromine into salts of potassium. After evaporation, the mass is calcined to expel organic matter.

Silvering Plate-glass by Lenoir's Amalgamating Process.—The silvering process of plate-glass ought to be preferred to ordinary amalgamating processes, both from a hygienic and economical point of view. Nevertheless, silvered glass presents certain defects not to be found to the same degree in glass treated with quicksilver. They have always a yellowish tint. The layer of silver does not adhere sufficiently to the glass; and it happens sometimes that this layer detaches itself to a greater or less extent, especially by exposure to the sun. Finally, sulpho-hydric action always ends by blackening the layer of silver, notwithstanding the protective coating of varnish with which it is covered.

M. LENOIR, the inventor of the gas-engine, has succeeded in rectifying some of the defects.

The plate-glass, silvered by any process, is washed, and then sprinkled with a diluted solution of cyanide of mercury and of potassium. The silver displaces a part of the mercury, and holds it partly in solution. The rest of the silver produces an amalgam of a much whiter colour, and possessing more adherence than the silver itself. This change is instantaneous.

The amalgamated glass has lost the yellowish tint, it is not so easily attacked by sulphurous emanations, and completely resists the action of light. *Debray, in Bull. de la Soc. d'Encouragement, &c.*

Persian Red Prepared in the Wet Way.—If carbonate of lead is digested with a cold solution of neutral chromate of potassia (one part of the chromate in 50 parts of water) in the proportion of two particles of carbonate of lead to one particle of the chromate, after two days a red crystalline precipitate of basic chromate of lead is formed, of the following composition:—

$$2\,CO^3\,Pb + CrO^4K^2 = CrO^4Pb.\,PbO + CO^3K^2CO^2.$$

The liquid contains bicarbonate of potassia. If afterwards the whole is boiled, a more basic chromate of lead, of a violet red, and neutral chromate of potassia, is formed, carbonic acid being disengaged at the same time.

The violet precipitate, if treated with 4 per cent. of its weight of sulphuric acid, diluted with 100 parts of water, is changed into a mixture of red chromate and sulphate. To prevent its being changed into chrome yellow by reaction, it is necessary to neutralize the acid liquid exactly by the soda. The red thus obtained is very bright. In place of sulphuric acid azotic acid or acetic acid may be employed.

The Depreciation of Silver.—Excess of production of and decrease in the demand for this precious metal are obviously the primary if not the sole causes of the continuous fall in the price of silver. The quantities extracted from the German mines alone, which are not comparable in richness to the Peruvian and North American, nor even the Spanish lodes, has increased during the nine years, from 1865 to 1873, in the following proportions: lbs. (metrical $= 1\frac{1}{10}$ avoidupoids) 146,692, 157,084, 176,651, 187,118, 184,535, 185,846, 196,201, 254,013, 354,421. A reaction, however, has taken place in 1874, and especially in 1875, during which the production has considerably receded; and this reaction is no doubt taking place on a larger scale in America, where the working expenses are so much more considerable than in Germany. *Zeitschrift für das Berg, Hütten- und Salinen-Wesen.*

Fatty Matter from the Seed of the Chinese Oil-Tree.—This tree (*Elæcocca Vernica*) belongs to the family of Euphorbiaceæ, and produces fruit with oleaginous seed pips. This seed being submitted to powerful pressure, an oil is obtained which is scarcely fluid, colourless, inodorous, and almost tasteless. Its density is 0·9362. It thickens at 18° below zero without crystallising. Ether will extract from the seed 41 per cent. of oil, presenting the same characteristics. But if, instead of ether, sulphide of carbon be used, the fatty matter obtained solidifies and shows a crystalline structure; it then melts at 34°, and presents the same composition as the liquid oil. Thence the sulphide of carbon must have caused an alteration. By heating

the oil in open air it also becomes solid, but in this case the phenomenon is entirely different, for the solidification takes place under absorption of oxygen, and the solid mass obtained is infusible at 200°, and scarcely soluble in ether and sulphuret of carbon.

However, if the air be shut out, light will effect a remarkable transformation on the oil, which then solidifies rather rapidly during two days' insolation. This transformation is due to the most refrangible rays of the spectrum. The solid matter thus formed, without an increase of weight, melts about 32° Cent.; it is quite neutral, like the oil itself, does not contain any free fatty acid, and does not leave glycerine with water.

This elæcocca oil is the most siccative known. When thinly spread, and exposed to the atmosphere on a glass-pane, it dries in a few hours. It is easily saponified by the alkalis. When treated by heat (air being excluded), with twice its weight of alcoholic potash of the fifth degree, the result is glycerine, and a soap, which being decomposed by phosphoric acid, yields two acids. One of these is liquid; the other crystallizes in rhomboidal lamels, which are fusible at 48°. The two acids are separated by squeezing through paper.

The solid acid is of a new kind, which the author terms *Margarolic acid.* It is insoluble in water, exceedingly soluble in ether, sulphuret of carbon, the carburets, and alcohol. This acid oxidises in the air, and forms a resinous and transparent varnish; the increase in weight is 8·5 per cent. It keeps under water. Its formula is $C^{17} H^{30} O^3$, as confirmed by the analysis of its salts of potassium, barium, lead, and silver. The salt of potassium crystallizes readily in hot alcohol. Its concentrated aqueous solution is decomposed by dilution, in leaving an acid salt which deposits in nacreous spangles.

The liquid acid, after being purified by its transformation into a calcareous salt, differs from every fatty acid known. The author calls it *elælic* acid. The lead salt is soluble in ether, whilst the *margarolate* of lead does not dissolve in it.

The saponification of the oil, hardened by light, produces a mixture of solid fatty acids, but no liquid acid. After a series of crystallizations in alcohol, an acid is obtained fusible at 72°, which the author proposes to name *stearolic.* (N.B. This appellation has already been given to the acid $C^{18} H^{32} O^2$ obtained by the action of alcoholised potash on monobromoleic acid.) This acid can be distilled *in vacuo.* It contains C = 74·30 per cent., H = 11·16, O = 14·54. *M. S. Cloëz, in the Bull. de la Soc. Chim. de Paris.*

A Recipe for Writing Ink.—The pharmaceutical chemist, ROQUE MOSCHINI, recommends the following ingredients:—

Lactate of iron . . .	1	gramme.
Gallic acid	0·60	„
Pulverized gum-arabic. .	5·00	„
Do. refined sugar .	2·00	„
Hot water	100·00	„

The whole to be mixed; and if care has been taken in the selection of the gum the ink obtained by this process will be found fluid, incorruptible, and congenial to the steel pen. *El Porvenir de la Industria.*

Removing Grease Stains from Fabrics.—The "Plata Industrial y Agricola" points out the erroneous practice of trying to take out stains by rubbing the spot with a sponge or rag, impregnated with benzine, turpentine, &c., by which *modus operandi* the greasy matter is only rubbed in and spread over a larger surface. A more rational and efficient mode would be to put the spotted fabric between two pieces of blotting paper, the upper one of which is saturated with the scouring essence, and then leaving it under suitable pressure the length of time necessary for dissolving and absorbing the fatty matter of the blot. *El Plata Industrial.*

Bronzing Iron.—The old processes, which are still used almost exclusively, are founded on the formation of an artificial layer of rust, and necessitate a long manipulation. A bronzed piece of machinery lately submitted to the Military Technical Committee at Vienna showed an appearance quite different from that generally observed on bronzed articles. Mr. HESS states that it was black, with a graphitic gloss on the surface, which was very hard, so as to bear the wire-brush. By analysis it was found that this coating was formed of ferroso-ferric oxide. The formation of this compound may take place in different ways. The piece may be painted with linseed oil, and then subjected to the action of heat, and thus a skin of magnetic oxide and carbon is produced. With articles which will not bear heating the coat is obtained by using Thirault's method, which consists in depositing on the iron a uniform coating of hydrated ferric oxide, and transforming this coating into ferroso-ferric oxide by dipping it in water heated to from 80° to 100°. It results from the researches of Mr. Hess that the bronzing is still more rapidly produced by putting the article for some time into an acidulated solution of ferrous chloride, by which a black pellicle of magnetic oxide is produced, which is made to adhere firmly to the surface of the piece by steeping it in hot water. After drying the piece may be painted with linseed oil or wax.

In the latter case, the magnetic coating is formed in consequence of the reductive action upon the ferric oxide and its salts:

$$4\,Fe^2\,O^3 + Fe = 3\,Fe^3\,O^4$$

The advantages of these new bronzing processes are, greater despatch and a better adhesion of the coating as compared with the old methods. Experiments on a small scale have shown that under certain unfavourable circumstances the iron bronzed by the new process may take to rust slightly, but this could be removed easily with the wire-brush, without injuring the bronzing. Never was there any rust found under the bronze coating which would cause it to scale off, as it frequently happens with the old process.

Mr. Hess further recommends the use of sulphide of copper for giving a very fine, brilliant, blue-black coating. The articles, having been well cleaned, are suspended for a few minutes in a solution of sulphate of copper, so as to cover them with a film of copper. The pieces are then washed in water and immersed for a few minutes in a solution of hyposulphite of soda slightly acidulated with hydrochloric acid. A coating of copper is thus produced which completely resists the action of air and water. The article is at once washed in water, dried with a cloth or filtering paper, and polished with a burnishing stick. The coating is beautifully steel-blue, adheres closely to the iron, stands the scratching-brush, and is proof against rust. *Deutsche Industrie Zeitung.*

Decomposition of Water by Platinum.—By heating cyanide of potassium along with black platinum and a small cup of water, in a tube, to 500° or 600° Cent. hydrogen is evolved, which is mixed with ammonia and oxide of carbon (4½ per cent. CO to 100 H), and platino cyanide of potassium is found. The hydrogen and oxide of carbon are formed according to the following equations:—

$$4\,K\,Cy + 2\,H^2\,O + Pt = Pt\,Cy^2\,2\,K\,Cy + 2\,K\,HO + H^2$$
$$2\,C\,Az\,K + 4\,H^2\,O = CO^3\,K^2 + 2\,Az\,H^3 + H^2 + CO.$$

A concentrated solution of cyanide of potassium is decomposed by the platinum according to the first equation. The reaction agrees with the thermo-chemical considerations, deduced from the absorption of caloric, consequent on the decomposition of the cyanide of potassium and the water, and from the heat set free by the formation of the potash.

The cyanide of mercury dissolved in water is not decomposed by platinum, even at ebullition. The addition of cyanide of potassium immediately causes the mercury to precipitate and to combine with the platinum. *MM. Sainte-Claire Deville and H. Debray, in the Bull. de la Soc. Chim. de Paris.*

Artificial Vanilla.—Vanilline, the chemical equivalent of vegetable vanilla, which has reached an exorbitant price, may now be obtained by several processes proposed by Messrs. TIEMANN, WASSERMANN and ERLENMEYER. According to the first of these chemists, the product of the oxidation of ethyleugenol obtained by Mr. Wassermann, contains ethylvanillic acid and a vanilla-scented body, which, he says, is nothing else but ethylvanilline. A simpler means for passing from eugenol to vanilline consists in oxidising the acetic derivative of eugenol. This *acetyleugenol* is obtained by the hot action of the acetic anhydride in eugenol. It forms an oily liquid, boiling at 270°, and, on cooling, concretes into nacreous spangles. Its oxidation furnishes large quantities of acetovanillic acid, with a little acetovanilline, which is easily separated by means of bisulphite of sodium and ether. These combinations can be transformed into vanillic acid and vanilline by the action of potash.

The synthesis of the *ferulic acid* is as follows. When acetic anhydride is made to act on sodium-vanilline, a compound is obtained analogous to coumarine, and which might be called *vanillo-coumarine.* Heated with potash, this compound turns into an acid which has been identified with the ferulic acid obtained from asafetida. Thus ferulic acid, $C^{10} H^{10} O^4$, represents hydroxylated and methylated cinnamic acid:—

$$C^6 H^3 - \begin{cases} CH=CH-COOH \\ OCH^3 \\ OH \end{cases}$$

and constitutes, in all probability, the acid corresponding to coniferylic acid.

This synthesis of ferulic acid confirms the relations pointed out by Mr. Erlenmeyer between this and the cinnamic and eugenic acids. This chemist also has obtained vanilline by the action of permanganate of potassium on eugenate of potassium, or even

potash by itself. In both cases a larger or lesser quantity is formed of crystallized polymere eugenol, which melts above 100°. The author thinks that the generation of this polymere precedes that of vanilline. *Deutsche Chem. Gesellschaft.*

Red Spots on Glue.—Herr KATHREINER reports that the reddening sometimes observed on glue is due to a chromogene bacteria, called the *Micrococcus prodigiose*. The fact was discovered by the help of the microscope, and verified by the inoculation of the parasite on boiled potatoes, which then assumed a cochineal tinge. *Bayerisches Industrie-und-Gewerbe-Blatt.* [It is probable that the red spots on the crust of the French *Brie* and other cheeses are due to the same cause. These red spots are called *cachets*, and the cheeses so "sealed" are preferred by the amateur of Brie, which forms such an important item in the lunch of the French workman.]

Velocity of the Electric Current.—Herr SIEMENS has reconstructed an apparatus he proposed more than thirty years ago, for measuring high velocities. In the case of electricity, the apparatus consists of a cylinder, revolving at a high speed, on which a spark is discharged directly from a Leyden jar, whilst, at the same moment, another discharge is sent through a long coil of wire, which terminates close to the same cylinder. The distance on the cylinder between the two marks caused by the electric fluid gives the means of calculating the speed of the current. Thus, for iron wire, Herr Siemens found it to be about 124,000 miles (240,000 kilometres) per second. Wheatstone, from experiments with his specular velocimeter, calculated the speed at 248,000 miles (480,000 kilometres) per second. *Dingler's Polyt. Journal.*

METHODS FOR DETECTING THE PRESENCE OF ARTIFICIAL COLOURING MATTER IN WINES.

FOR some years past the wine trade has been in a state of alarm, in consequence of the large quantities of wine which have been ascertained to be coloured artificially by means of chemical substances, such as fuchsine, which is extracted from coal-tar and is used for dyeing red and rose pink. At Nancy, in several towns of Alsace-Lorraine, in the south of France, and quite recently at Paris, wine has been seized—provisionally sequestered—on suspicion of adulteration. An official analysis having taken place, these wines were found to be adulterated with fuchsine, which was intended either to impart a richer tint to the beverage, or to give the vinous *robe* to mixtures which only contained a few elements of the juice of the grape. It is a positive fact that in Alsace-Lorraine they manufacture, ostensibly and wholesale, beverages which only have the name of wine. Pungent decoctions (*riquettes*) which, like "husband's tea," are obtained from the residue of the wine-press, are made to ferment once more by the addition of water diluted with glucose, thus producing an alcoholic liquid, which is artificially coloured by caramel or with althæa (the arborescent hollyhock or rose mallow), cochineal, orchil, elder-berries, phytolaque, fuchsine, &c., and these wines are then labelled and sent into the market as growths of different localities and ages. The lighter wines of the south of France, sometimes called "lowland" wines (*vins de la plaine*), often are merely wines of a second pressing, with an addition of colouring matter and tartaric acid. The wines exported to France from Italy and Spain are all artificially coloured with elderberries and tartaric acid. Things have gone so far that the syndicate of the wine-growers at Narbonne have petitioned the Minister of Agriculture to prohibit the importation of Spanish wines. In a letter from M. Paul Massot, deputy of the Pyrénées-Orientales, to the Minister of Justice, this gentleman points out the facts which are so important to the public, and stigmatizes the perpetrators of these criminal frauds. "The Spanish, Portuguese, and Italian wines," says M. Massot, "which are tinted with bays, have for a long time competed in a way fatal to the French produce; but this fraud, having been adopted, imitated, and improved upon by a large number of unscrupulous French merchants, or which, perhaps, has already been employed by certain proprietors in districts where the vintage is the most abundant, has taken such an extension, that the finest wines of the Narbonne, Lot, Gironde, and especially the Roussillon districts, are now completely abandoned. The druggers, who formerly constituted an imperceptible minority in the wine-growing world, generally only used to employ harmless vegetable substances. They have become legion now, and are not afraid of using poisons. Fuchsine is consumed by the hundredweight. Grenat or garnet, a secondary product of the manufacture of fuchsine, used to be unsaleable, but is now sold at a remunerative price; and the reason for it is obvious—there are very few products sold for colouring wines under such fancy names as colorine, caramel, &c., but contain aniline, salts of rosaniline, or residues of fuchsine."

M. Massot gives the particulars to show to what degree public health is jeopardized by this immense system of adulteration. The "Annales d'Hygiène Publique" state that in the village of Odeillan alone a Narbonne grocer has sold 10,000 fr. (£400) worth of ammoniacal cochineal. Small dealers are known to clear as much as 30,000 fr. (£1,200) profits from the sale of wine-colouring matter.

A great number of these preparations are injurious to public health, and if the others, almost all of them laxative, might be considered as inoffensive—a thing evidently impossible, since upwards of seven grammes (¼ oz.) of alum has been found in a litre of wine coloured by elder-berries—they all constitute a fraud which the magistrate is in duty bound to repress.

The Custom-house officers and excisemen, who used to judge wines by the look, and taste them with their *tasse* (a flat silver saucer, with a finger-handle), being unable to detect whether wines had been so drugged in the manner stated, chemistry had to be resorted to.

Chemists hitherto had great difficulty to discover with certainty the nature of the tinctorial matters used for that purpose. Under the pressure of circumstances and the gravity of the facts, some *savants*, however, have succeeded in devising special methods, which allow any person to detect the nature of the spurious compounds fraudulently added to wines for brightening their colour, or entirely changing it. M. V. Didelot, a druggist at Nancy, has quite recently published a book under the title, "Processes for Detecting the Adulteration of Wines," which contains several practical recipes easy to be understood and followed.

In order to find out the colouring matters M. Didelot puts into a liqueur glass a small ball of gun-cotton, with 10 or 15 grammes (⅓-½ oz.) of wine. The glass is shaken for a few seconds, and the cotton then washed. If the wine is pure, or what may be termed "achrozotic," the cotton comes out white; otherwise it remains coloured by the fuchsine or other tinctorial matter. In case there should be any doubt, or the coloration of the cotton be not decisive enough, M. Didelot advises to put the gun-cotton into a small tube and heat the same with a spirit lamp, which will produce the reaction with all the preciseness desirable.

Gun-cotton indicates nearly every dyeing matter superadded to wine. With a few drops of ammonia it is even possible to determine the matter used. Thus, a few drops of it sprinkled on the gun-cotton decolour it if it has been dyed by fuchsinated wine. It takes a violet tint when the wine has been coloured by means of orchil, and a greenish hue when it has been adulterated with hollyhock leaves or the stalky mallow.

This process, however, would be defective if the wine had been drugged, not with one, but several substances. A separate process in that case is requisite for each of the matters looked for. Fuchsine being the most dangerous of tinctorials, owing to being often prepared from aniline and by means of arsenic acid, M. Didelot gives us a special method for the discovery of that chemical.

This method consists in pouring into a test-glass closed by a tap, or into a glass funnel closed by a stopper, 10 to 15 grammes (⅓-½ oz.) of the sophisticated wine, adding to it several grammes of ammonia and about five grammes of sulphuric ether. The whole is then well shaken, and left at rest for a few minutes, after which the liquid is decanted by the tap so as to draw off the supernatant ether. This ether is poured on a small ball of gun-cotton, and then some drops of acetic acid or strong vinegar are spilt on it. When there is fuchsine in the wine the azotic cotton at once assumes a rosy tint. When no funnel or test-glass is at hand, the mixture of wine, ammonia, and ether is shaken in a common liqueur glass and let alone for some minutes. A small bit of gun-cotton is steeped in the supernatant ether, put on a plate or saucer, and some vinegar dropped on it. The presence of fuchsine is proved by the cotton thus treated showing a rose-pink colour.

An Italian chemist, M. Lamaltina, has communicated a process which differs from M. Didelot's. Fifteen grammes (½ oz.) of peroxide of manganese, coarsely pulverized, is mixed with 100 grammes (about 3½ oz.) of wine, the mixture to be shaken for a quarter of an hour. It is then filtered, and if the wine comes out colourless it is pure, but if it keeps its colour it certainly has been coloured artificially. This process is said to be

excellent, provided the peroxide of manganese be pure. Care must be taken not to employ ferruginous manganese, for the acids and salts in the wine would dissolve the iron and thus interfere with the re-actions.

Another chemical agent (chloroform) may be used for detecting fuchsine and other fraudulent matter in the wine. Three or four grammes weight of wine, as much water, and about two grammes of chloroform, are poured into a tube, closed at one orifice. The tube is then thoroughly shaken, closing it at the other end with the thumb, and leaving it to settle for a few minutes. The chloroform precipitates at the bottom of the tube, bringing down a portion of the artificial colouring matter held in the wine. With pure wines, chloroform produces a light grey, slightly rosy, half transparent or diaphanous precipitate, which separates into two strata, the lower of which becomes limpid after a few hours' rest.

The addition of one centigramme of fuchsine to wine yields, with chloroform, a characteristic precipitate of a rosy violet shade, which grows richer as more fuchsine is added. After several hours' settling the precipitate separates, and the lower portion clarifies.

The precipitate produced by chloroform on orchil is of a bluish grey, turning into a red brown in the lapse of a few hours, darkening with time, and never separating.

With the same test, cochineal produces a dirty grey and rather violet precipitate; the *rose trémière*, or hollyhock, a violet rose. The simultaneous presence of orchil and fuchsine turns the results of the latter into a brownish red precipitate. Caramel (burnt sugar) gives the characteristics of fuchsine and orchil combined—a dark violet-red precipitate. For want of chloroform benzine may be used. The reactions in this case are nearly the same, only the colouring matter supernatates, and forms a kind of jelly with the benzine. M. Paul Massot justly demands that the law against sophistication of wine should be made as strict, and enforced as severely, as is done now in reference to other articles of food; and he suggests, that at the opening of the Chambers a special bill be brought in to efficiently put down these scandalous practices, which are so injurious to public health, and sap the reputation and prosperity of the wine trade in France, and elsewhere, at its very foundation.

PRIZE Competitions in France.—At the August, 1877, meeting of the Société Industrielle de Reims, gold and silver medals, to be supplemented by pecuniary rewards in cases of extraordinary results or exertions, will be given to the successful competitors in the branches of industry defined by the programme of which we subjoin an extract. The candidates' papers must be sent in on or before the 15th of June, 1877, addressed to the secretary of the society, 18, Rue Ponsardin, Reims, under the usual epigraphed envelope, and enclosing the name, address, and profession of the candidate.

1st Question, Gold Medal. A paper on the motive power practically required for working each machine for combing, spinning, and weaving wool.

2nd Question, Gold Medal. For a practical manual for the working of wool self-actors.

3rd Question, Silver Medal. For a pyrometer to indicate with sufficient approximate accuracy, and without trouble, the temperature of gases at any point of the flue, at their escape, or at the base of the chimney.

4th Question, Gold Medal. For determining the influence of singeing on the dye of merinos, and giving the comparative results of actual experiments of gas and plate-singeing. The influence of dressing or sizing in general on the dye of woollens, compared with that of the several kinds of sizes used in the manufactures.

5th Question, Gold Medal. For a practical apparatus for charging the air of spinning mills with moistness in a uniform manner, without causing drought or condensation of vapour on the machinery, without excessively raising or lowering the temperature of the rooms, and not requiring more motive power than that represented by the steam injected into the rooms by the usual contrivances.

6th Question, Silver Medal. (Only of local interest.)

7th Question, Gold Medal. For any invention by which a noteworthy progress has been realized in one of the branches of woollen manufactures, viz., combing, spinning, weaving, and finishing.

8th Question, Silver Medal. For a process of scouring carded wool on bobbins without injuring the yarn, and scouring it in a complete and uniform manner.

9th and 10th Questions, Gold Medal. (Educational and local.)

Engineering, Building, &c.

ABSTRACTS FROM FOREIGN PERIODICALS.

PECULIAR Corrosion of a Steam Boiler.—In a newly established mill in Hungary it was remarked, a short time after the starting of the engine, that the boilers had considerable leaks, which so rapidly increased that it was necessary to change the heaters, although they were almost new. When inspected it was seen that the plates, 7 millimetres (¼ in.) thick, were completely pierced in some parts, and in others corroded to a depth of 4 millimetres (0·156 in.). The boiler was untouched, and slightly covered with a layer of tartar. The cavities caused by the corrosion were filled with a greasy substance, brown coloured, mostly composed of oxide of iron, besides fatty matter, carbon, and mineral substances. The fatty matter, treated by ether, was dissolved; after evaporation of the ether there remained a brown and clammy mass, insoluble in water, and which, analysed, was found to be oleate of iron. Oleic acid was easily detected by saponification with baryta; there was no glycerine, and, consequently, no neutral fat.

By a mixture of free oleic acid, for some time exposed to air, with water and iron filings, the intervention of heat develops a violent current of hydrogen, and a residuum of oleate of iron, containing 11 per cent. of oxide, in no way different from the matter found in the boiler. This synthetic trial may then afford a very clear explanation of the fact above mentioned.

In the mill referred to, returning steam was used to warm the water, which occasioned a dragging away of oleic acid proceeding from the cylinder and the engine condenser. Arrived in the boiler, this matter was deposited as clammy drops, and under the high pressure attacked the metal with which it was in contact. The oleate thus formed was distributed through all the lump, and came into contact with the hot water; it was then decomposed in oxide of iron and free fat acid, which again attacked the metal, penetrating more and more; after some time the iron plate was thus perforated and caused the leakage. Thus is explained this rapid deteriorating action, able to destroy in a short time an iron plate 7 millimetres thick. It is then of the utmost importance to pay the closest attention to the nature of the water, and it is seen how essential it is to rid from the grease it may contain that which comes from the condensers, and which is generally used in all condensing engines. *Revue Industrielle, 11th Oct.* 1876.

Bending Iron Tubes.—Wrought-iron tubes are now usually employed for water and high-pressure steam pipes. This arises from the relative cheapness of these tubes, compared with copper and cast-iron ones. Moreover, experience has taught that in certain cases, as in the installation of pistons, for instance, they are much preferable to others. Unfortunately, the bending of such pipes is very difficult to perform in a convenient manner, and if the workman is not skilful, flattenings or swellings, detrimental to the strength, are produced. It may then be useful to point out a simple means to perform the bending of iron pipes down to a diameter of 200 millimetres (6 in.).

After having marked with chalk the place where the curve is to be, this part is heated externally above a forge fire, with slight blast, taking good care not to let the interior part be heated. This result is easily obtained by not having the pipe covered by the fire, but keeping it only suspended above, and moving it forward and backward to regularly heat the whole length. When a dark red temperature has been reached the pipe is withdrawn from the fire, one of its ends is thrust in a hole, the diameter of which is the same as that of the pipe; then it is carefully pressed down, the part not heated remaining inside. If depressions are produced the bending must be immediately interrupted and the tube be heated again. It is necessary to avoid frequently reheating in the same place as much as possible, and never to let the tubes cool during the interval of two heatings.

In this way, and taking such precautions, curves of any radius may be obtained without the intervention of rosin or sand. *Revue Industrielle, Oct. 11th,* 1876.

A Large Ingot of Silver.—The banking firm, Messrs. Pio Bernegello and Co., of Mexico, exhibit in the Mexican department at the Philadelphia Exhibition a mass of pure silver 3 ft. wide and 1 ft. thick, weighing 2,330 kilogrammes (about 2¼ tons) and valued at 320,000 fr. (£12,800). *El Plata Industrial y Agricola.*

The Inter-Continental Tunnel.—This submarine tunnel, by which Spain and Europe will be united to Africa, continues to occupy public attention in Spain. The starting-

point will be between Tarifa and Algesiras, at the foot of the peaks of Nuestra Señora de la Luz, and the tunnel will emerge in Africa between Tangiers and Ceuta, in the neighbourhood of Sierra Buyones at Cape Cires, some 18 kilometres (11 miles) from Mount Hacho. The tunnel will form a straight gallery 7 metres wide and 7 metres high, and will be worked by stationary engines. The crust of earth to be left above the ceiling being fixed at 81 metres in thickness, and the maximum depth of the Straits being 819, the shaft will have to be laid some 900 metres (2,940 ft.) below the level of the sea. The depths of the Mediterranean are from 1,100 to 4,540 metres, and those of the ocean from 1,000 to 7,000 metres. The intercontinental tunnel would form the direct route to India; Alexandria might be reached from London in 100 hours, from Paris in 90, and from Algesiras in 48. From Ceuta to Alexandria the railway would pass through 280 kilometres of Moroccan territory, 730 through Algeria, 291 through Tunis, 1,012 through Tripoli, and 200 in Egypt. *El Porvenir de la Industria.*

USE of Chloride of Calcium for Watering Streets.—For some time past it has been proposed to make use of a weak solution of some deliquescent salt for watering the streets of large towns. Chloride of calcium, which has no commercial value, and is even regarded as an obstruction in some works, seems naturally adapted to this purpose. During the last few years trials have been made at Rome, the principal streets of which are watered with a solution of chloride of calcium obtained from the numerous pyroligneous acid works in the neighbourhood. The results are reported to be highly satisfactory. The dampness communicated to the road, instead of disappearing in a few hours, as is the case when water alone is used, remains for a whole week, the road continuing damp without being muddy, and presenting a hard surface on which neither the wind nor the passing of pedestrians or horses has any effect. In the course of time, too, the road becomes covered with a sort of crust, which adds to the durability of the surface.

The use of this solution shows a saving over that of water alone, which M. Houzeau, in a recent communication to the Académie des Sciences, estimates at over thirty per cent. The same authority also attributes to this method of watering the streets hygienic qualities which deserve consideration. The chloride of calcium obtained from the pyroligneous acid works always contains appreciable quantities of perchlorate of iron and tarry matters, the volatilization of which in the air cannot but be salutary. Lastly, the complete suppression of dust constitutes a considerable improvement in the conditions capable of exercising an influence on public health.

A NEW Metal.—A new compound metal, which promises to prove of considerable value in mechanical construction, has recently been introduced to public notice under the name of "manganese bronze." This metal owes its origin to Mr. P. M. Parsons, who is the inventor of another useful metal known as "white brass," and is made by the White Brass Company, of Lombard Street, Southwark. It is produced by mixing manganese in certain proportions with molten bronze, the result of which is a material of great toughness and possessing remarkable resistance to tensional strain. The new alloy is advantageously used in a variety of cases where gun-metal, bronze, and yellow-metal are ordinarily applied. In a molten condition it is readily cast into any required shape, and in this form it is stated to exceed the best gun-metal in strength and toughness by about 50 per cent., and to be about equal to wrought iron of average quality. It can also be forged or rolled at a red heat and drawn into tubes or wire, its strength being increased to that of mild steel by this process, and its toughness being brought nearly up to that of copper. It can also be made to various degrees of hardness. Samples of this metal were tried at the Royal Gun Factories, Woolwich Arsenal, when No. 1 quality was found to have an ultimate tensile strength of 24·3 tons per square inch, an elastic limit of 14 tons per square inch, and to stretch nearly 9 per cent. of its length before breaking. No. 2 quality, which is slightly harder than No. 1, has a high elastic limit of nearly 17 tons per square inch, an ultimate tensile strength of 23·6 tons per square inch, the elongation being ·076 in two inches, although there was a slight flaw in the specimen. The specimens were those of cast metal, and by forging or rolling either quality at a red heat they are stated to acquire a tensile strength of from 29 to 30 tons per square inch, and to stretch from 20 to 30 per cent. of their length before breaking. Some samples of the metal were exhibited at the recent meeting of the Iron and Steel Institute.

ON SOME ASPECTS OF THE COMMERCIAL VALUE OF SCIENTIFIC RESEARCH DURING THE PAST HALF CENTURY.

THIS present century has been most emphatically the age of progress; and to no department of the arts or manufactures can we turn without being astonished, when we consider the vast changes and improvements which it has of late years undergone. To the intelligent observer, one of the most interesting features of these changes and improvements will be the constantly increasing influence upon them of the results of scientific knowledge and research. In the days of our grandfathers, the man of science was looked upon to a very great extent as a harmless dreamer, whose labours could have no possible influence upon the practical occupations of every-day life; but at the present time he is consulted with anxious interest by commercial men and manufacturers of all classes, who are willing to purchase the benefit of his knowledge and experience at no scanty price, while at every turn we meet with classes and institutes where our workmen may obtain instruction in those branches of science which are most closely related to their respective occupations.

In the present paper, we propose to place before our readers a brief review of the most important of those scientific discoveries of the past fifty years which have a distinct commercial value, and have influenced to any extent the progress of our commerce, arts, and manufactures. Some few of these have more or less completely revolutionized the manufactures which they affect, while others have originated arts which were before unknown.

The science of chemistry has always been necessarily more or less allied with the manufacturing arts; and during the past half century its votaries have been by no means idle in their endeavours to render the commercial world still more beholden to their labours. It would be impossible in this short paper even to enumerate the various minor discoveries and improvements of commercial value which have been recently made in this department, but some one or two stand so prominently forward as to demand our recognition. The attention of chemists has been largely given, for a considerable period, to the utilization of those vast accumulations of waste material which result from the manufacture of many of our chemical products; and in the case of the coal-tar—so extensively produced in our gas-works—their efforts have been crowned with the most abundant success. We allude to the discovery of those well-known aniline dyes, which, although now familiar to every household, were twenty years since unknown. These beautiful and powerful colouring agents, which owe their discovery entirely to chemical research, are now manufactured upon a most extensive scale, and bid fair to revolutionize the whole art of dyeing.

The coal-tar products comprise a vast number of highly complex organic compounds, and the problem with chemists has long been to turn these products to useful account. Two of these compounds are benzol and toluol; and to Mr. Perkins is due the discovery, that from these the now well-known and important aniline compounds may be efficiently and cheaply manufactured. Another important result, which has considerably benefited the same art, is the more recent discovery, that alizarine, the colouring principle of madder, can be advantageously produced from the same source. Although it has but a slight commercial value, we cannot altogether pass over in silence another important chemical discovery, that of the powerful anæsthetic, chloroform, which has since given such valuable and extensive relief to the ills of suffering humanity. In addition to these more important practical results of chemical research, the past half century has been exceedingly fruitful of methods by which the cost and time employed in the manufacture of many commercial products—such, for instance, as soda and bleaching powder—have been considerably reduced, and whereby also many of the hitherto waste products have been utilized. Still there is a vast field open to the explorer, and yet richer mines of useful knowledge, doubtless, still remain unopened. Great attention is still being paid to the coal-tar products, in the hope of discovering a method whereby that most valuable medicinal product, quinine, may be successfully and cheaply manufactured from them; and the fortunate discoverer of such a method will confer no small favour upon the human race, and will in a more literal sense reach a rich harvest of reward. The art of tanning also deserves, and doubtless to a great extent has, the consideration of the practical chemist. The operation of converting a skin or hide into leather depends upon the combination of tannic acid with the gelatinous true skin of the animal, whereby

an insoluble substance is formed. This process has hitherto been an exceedingly slow one, occupying several months in its completion, and involving the locking up for that period of extensive capital. Several methods have indeed been devised, whereby the process has been considerably shortened; but in all instances it is found that, owing to the union between the tannic acid and the gelatine being imperfect, the leather thus produced is much inferior to that obtained by the older and more tedious process. A quick and at the same time effectual method of tanning is therefore still a desideratum, and one the discovery of which would be well repaid.

Turning from chemistry to the somewhat kindred science of physics, we are at once confronted with that which must unquestionably be regarded as one of the grandest adaptations of scientific discovery to the wants of commercial and civilized life. We allude to that great world-wonder the electric telegraph, whereby time and space have been annihilated and the influence of which upon our social and commercial life can never be truly estimated.

Fifty-six years ago the apparently trifling discovery was made that when a magnetic needle was placed within the influence of an electric current it was thereby deflected from its natural position. It was not, however, until 1837 that a system of telegraphy sufficiently perfect for practical purposes was based upon this discovery. In that year Wheatstone and Cooke succeeded in introducing the telegraphic system into England, and the rapidity with which that, which was at first but a scientific toy, has developed into one of the most wonderful and most perfect instruments which the world has ever seen, is one of the most striking proofs which can be adduced of the rapidity with which scientific discovery has of late proceeded. Improvement after improvement has been made in the structure of instruments and the working of the system until the efforts of inventive genius have culminated in what is known as the "duplex" system, by means of which six or eight messages may be sent in opposite directions at the same time upon a single wire. Time would fail to enumerate even the various steps in this most brilliant series of discoveries, and we can stop only to mention one or two of the most noteworthy. In 1836 Professor Morse brought out his recording instrument, by means of which the messages are stamped by a series of dots and lines upon a slip of paper, thus forming a record of the message and a valuable means of detecting errors. Various improvements have been made in this ingenious instrument, and a modification of it is very extensively used in our postal and other telegraphs. In 1850 the first submarine cable was laid from Dover to Calais, but survived only a day. In 1851 the attempt was successfully renewed. In 1866, after several failures, the vast and apparently chimerical undertaking of connecting England and America by means of an Atlantic cable was brought to a successful issue, and at the present day two cables stretch from Ireland to America through which messages are daily sent at the rate of about fourteen words a minute. In addition we have cables connecting almost all parts of the civilized word with each other, and the reception of a telegram from India or New York is looked upon as a perfectly natural and common occurrence, provoking neither emotion nor surprise. These facts are so well known and we are so familiar with these phenomena that we have forgotten to wonder at them; but we should not forget the vast debt of gratitude which we owe to the pioneers in these noble discoveries—men, for the most part, who for no selfish ends, but out of pure love for science, prosecuted with dauntless energy those researches which led to results as valuable as they were unexpected.

In the other branches of physics discoveries of perhaps even greater theoretical importance have been made, but, with one exception, none of these have received more than a very limited commercial application. The exception to which we allude is the beautiful art of photography, which affords another instance of the rapid development of an apparently simple discovery.

So long ago as the commencement of the present century, it was considered probable that the blackening effect which light has upon the salts of silver might lead to some important discovery, whereby permanent representations of objects might be obtained by the employment of solar light. The matter, however, languished until, in 1839, the social world was startled by the introduction of the daguerreotype process of what is now aptly termed photography, or sun painting. This process, which consisted in obtaining an image upon a plate of copper, coated with iodide of silver and exposed to the action of the sun's rays in a camera, speedily gave way to an improved method, whereby images were more readily and more cheaply obtained on glass, and finally upon paper. When this discovery was first brought forward it was mainly, if not entirely, applied to the satisfaction of that desire, apparently inherent in human nature, of having a permanent and faithful transcript of the features of acquaintances and friends, and "to have one's likeness taken" became a perfect rage. Photographers set up their "studios" in every conceivable position, and for a considerable period were thronged with visitors. Of late years, however, the process has been developed into a high art, and all the skill and labour of eminent engravers and others have been lavished upon it with the most successful results; and in its application to the higher purpose of producing copies of the most beautiful works of nature and of art, thus bringing within the reach of the masses transcripts of these works, the marvellous cheapness of which is surpassed only by their fidelity, it may be said to have created a new and most valuable branch of art. The extensive use which has been made of photography in disseminating copies of the treasures of art all over the world, is almost entirely due to the invention of the Woodburytype and its kindred processes. By means of this invention copies of photographs are printed with ordinary ink, and can be multiplied at an exceedingly cheap rate—impressions being produced which are as sharp as silver prints, and far more durable.

The labours of the physicist in the more theoretical branches of his profession have been crowned with most abundant success, and we have but to mention spectrum analysis, the mechanical equivalent of heat, the polarization of light, and with them the names of Roscoe, Joule, Tyndall and others, to prove our assertion. These however, although of the highest theoretical importance, are at present but of small commercial value; spectrum analysis is of slight service to the founder, and the polarization of light forms the scientific principle of the saccharometer, by means of which the value of saccharine fluids may be estimated. But if these discoveries have as yet no commercial value it is in the highest degree unwise even for the strict utilitarian to despise them. They afford conclusive evidence of the fact that scientific research is rife amongst us, and should assure us that their discoverers will not be likely to miss anything which will prove of commercial value. In the department of natural history, or, as it is now termed, "biology," the commercial man would least expect to find anything which could be of service to him, but even here discoveries have been recently made which will doubtless eventually lead to results which will stand him in good stead. The extensive investigations which have been and are still being made into the nature and mode of growth of the lowest forms of vegetable life, and especially of those which are parasitic upon higher plants or animals, have proved conclusively that many of the diseases of plants and animals are caused by the rapid growth within them of low forms of vegetable life. These spread through the various tissues of the body with marvellous rapidity, and produce those disastrous effects with which we are unfortunately far too familiar in the potato disease, the silkworm disease, and others, and in all probability they are also the cause of diseases such as cowpox, smallpox, &c., which, under the name of contagious diseases, affect the higher animals and man. Although up to the present time no absolutely practical result has flowed from these discoveries, yet there can be but little doubt that when the nature, mode of existence, and other facts connected with these parasites shall have been more thoroughly investigated, some highly beneficial results will follow, and if the labours of biologists should put us in the way of stamping out the potato disease alone they would confer a benefit upon mankind which it is impossible to estimate.

When we turn to the field of applied mechanics we are utterly at a loss for language to express the numerous and important improvements and inventions which the last half century has seen. Their name is simply legion, and to attempt to classify them even would be a task totally beyond the scope of this article.

The steam engine, in its various adaptations to the purposes of manufacture and commerce, has been vastly improved, and from a comparatively crude and imperfect machine has been brought to such a pitch of perfection that it seems as if there could be nothing more about it to improve. Any one who has taken advantage of the opportunity which has been offered during the past few months at South Kensington of comparing the engines, and especially the locomotives, of fifty years since with those of to-day must have been struck with the enormous strides which this branch of scientific industry has made; and when we remember the fact that fifty years have not yet elapsed since the first railway in Great Britain was opened, and look at the enormous network of lines which now cover our own and other countries, the effect is such as to produce astonishment in the mind even of the most superficial thinker.

Fifty-two years ago the first locomotive ever constructed travelled at the rate of six miles per hour. Five years after the "Rocket" travelled at the then enormous rate of fifteen miles per hour, while at the present time we consider anything below forty or fifty miles per hour intolerably slow. In addition to this rapid increase in the facility for travelling or transporting merchan-

dize by land, improvements quite as wonderful and complete have been made in our means of transporting goods by water.

The last half century has seen a total change in the construction and motive power of our ships, and consequently in the time which they occupy in their journeys. By the powerful aid of steam, voyages which formerly took weeks are now performed in as many days, and the opportunities for commercial intercourse between distant parts of the world which existed fifty years ago cannot be compared with the facilities which now obtain. In considering the great increase of these facilities we cannot pass over in silence the successful completion of the Suez Canal, by which intercourse with the East is so considerably facilitated, and which is another debt the world owes to the noble science of engineering.

The invention of machinery in general and its application to all branches of manufacture have kept pace with this rapid development of the railway and ocean steam systems, and the methods of production of the great majority of our articles of manufacture have been entirely and permanently changed. The past half century, and especially the latter part of it, has been most prolific in the production of countless machines adapted to manufacturing, and even domestic, purposes —machines which mainly perform their part with a precision and a rapidity which the most skilful workman would hopelessly attempt to emulate.

In estimating the value of these great improvements it should be borne in mind that they are nearly all more or less due to the labours of scientific men. It is true that the successful manner in which they have been carried out is due to the skill of our manufacturers and of their workmen, but for the principles upon which they are constructed, and upon which their value depends, we are indebted in the great majority of instances to the discoveries of those great men who have devoted themselves to this branch of science—many of the principles depending upon the solution of mathematical problems of considerable profundity.

In the foregoing remarks we have endeavoured to sketch a very general and rough outline of the progress of what we may term commercial science during the past half century, and had space permitted many other improvements and inventions, which though less noteworthy, are by no means unimportant, could have been shown to be due to the labours of men of science. Such, for instance, as the vast improvements which have been made in the lenses and lamps of lighthouses, and the investigations which have been made by Professor Tyndall with the object of securing more efficient fog signals for our coasts. These and similar improvements may or may not have a direct influence upon commerce or manufactures, but their indirect influence must be most considerable, rendering the exchange of commodities between distant countries far less precarious than it would otherwise be, and thus affording an additional stimulus and security to the commercial world.

And now, in closing this brief review, it will be well for us to pause and see if there be no lessons to be learned from these events of the last fifty years. First and foremost, we are impressed with the necessity, which is now more than ever apparent, for the manufacturer and the artisan to be also a man of science. Rule of thumb is rapidly giving way to scientific knowledge, and the man who is deficient in this latter cannot hope to win the race. A depressed state of general trade gives us the opportunity of comparing our knowledge with that of our continental neighbours; and with all our advantages we must reluctantly admit that we do not hold so prominent a position in the arts and manufactures as we formerly did. Nor is the reason hard to discover. The English mechanic has not lost his skill nor his strength, but he is insufficiently accoutred for the race, inasmuch as, with some few exceptions, he is almost totally destitute of that scientific knowledge of which his continental brother has so large a share. In most of those arts and manufactures in which hitherto England has held the foremost place, she is being gradually but surely outstripped by foreign nations, who both in price and quality can surpass her; and although difference of wages and cost of production generally have much to do with this, yet it is perfectly certain that much is also due to the fact that the foreign workman has a sound basis of scientific knowledge to assist him, while the English workman works mostly in the old ruts in which his predecessors have installed him. A contemplation, therefore, of the close connection which now exists between science and the manufacturing arts should impress all concerned with the necessity of increasing the facilities which already exist for the attainment, by their workmen and themselves, of a more substantial scientific knowledge, and above all it should teach us not to undervalue the labours of that noble band of scientists to whom we owe so much.

ENAMELLED Cooking Vessels.—At the meeting of the Society of Public Analysts, recently held in Glasgow, Mr. R. R. Tatlock read a paper on "Enamelled Cooking Vessels," in which he stated that in some instances the milk-white porcelainous enamel with which cast-iron cooking vessels are now so commonly prepared, is of such a character as to be objectionable in the highest degree, on account of the easy action upon it of acid fruits, common salt, and other ordinary dietetic substances, by means of which lead, and even arsenic, are dissolved out in large quantity during cooking operations. The following analyses were given of three enamels, the samples having been taken from three cast-iron pots made by different manufacturers:—

	No. 1.	No. 2.	No. 3.
Silica	61·00	42·40	42·06
Alumina	8·00	2·88	6·06
Oxide of Iron	1·10	2·04	4·04
Lime	3·02	·16	·78
Magnesia	·28	·10	·21
Oxide of Lead	Absent	25·89	18·48
Potash	5·61	7·99	6·46
Soda	20·67	14·67	19·25
Phosphoric acid	Trace	Trace	Trace
Arsenious acid	·02	·42	1·02
Carbonic acid	·30	Absent	Absent
Borax	Absent	3·45	1·70
	100·	100·	100·
Total bases	38·58	53·73	55·28

The author showed that it is not so much on account of the presence of large proportions of lead and arsenic that the enamels are so objectionable, but because they are so highly basic in their character that they are readily acted upon by feebly acid solutions, the lead and arsenic being thereby easily dissolved out. He showed that the ratio of the bases to the silica in the No. 1 was as 1 to 1·58; in the No. 2, as 1 to 0·79; and in the No. 3, as 1 to 0·76. A 1 per cent. solution of citric acid, boiled in No. 1, did not affect it in the slightest, while in the case of the No. 3, the glassy surface of the enamel was at once roughened and destroyed, and lead dissolved out to such an extent as to give immediately a dense black precipitate, with sulphuretted hydrogen. He thought that no enamel should be admitted to use unless it was totally unaffected by boiling with a 1 per cent. solution of citric acid, which was a very moderate test.

PAVING from Furnace Slag.—There is now a possibility of the "Staffordshire oysters," as the scoriæ from blast furnaces are facetiously called in that district, being turned to profitable account. Mr. Joseph Woodward, of Bedale, Yorkshire, having patented an invention for making the scoriæ into blocks for road and footpath pavement, has put down a plant at Messrs. Turley's blast furnaces, the Factory, Tipton, in order to produce blocks for the purpose. The molten slag runs from the furnaces into moulds, which are fixed upon a rotary frame, and as fast as one mould is filled another presents itself to the stream. The moulds are opened whilst the blocks are red-hot, and placed in a kiln at a certain heat, and there they stay for twenty-four hours. This is all the process, and it requires two men and two boys to use up thirty tons of slag per day. When ready for use the blocks are very clean and very hard. They turn a chisel, and the inventor claims for them that they are impervious to wet, and consequently to frost; the surface is level, but of such a nature that it bites the iron of the horse's shoes; the surface is chamfered, and so no horse could slip, whilst the chamfering, provided the street were laid upon a convenient gradient, would render the pavement a self-cleansing one. The blocks are made in five sizes in order to provide for different purposes, are cheap, and Mr. Woodward's effort to utilize the slag is the most successful which has been seen in South Staffordshire and East Worcestershire.

THE Ventilation of Railway Carriages.—According to the German papers, the railway companies having to a great extent neglected to provide their rolling-stock with suitable contrivances for renewing the air vitiated by combustion in the caloriferes, respiration, &c., the Government has lately resolved to take action in the matter. The railway companies have, therefore, a short time since, been directed to give their full attention to the question of ventilation, with a view to obviate the chief defects of the present modes—dust and draughts. Nine different systems have been proposed and are on their trial, one of them being already reported to act most

efficiently in connection with warming by steam. Some saloon and post carriages have been provided at the tops with a kind of dome or lantern, having adjustable or movable louvres. Nine railways have adopted higher door-windows (*erhöhte Thürfenster*), and five have fitted their first and second-class carriages with openings or windows (*Einsatzfenster*) of wire gauze. The Imperial Railway Office has ordered the experiments to be extended over two years, after which reports on the different systems will be received and examined.

THE Amber Trade.—The sales of this fossil have risen from 1,400 cwts. in 1874 to 2,000 cwts. in 1875. The merchantable article may be divided into four classes—viz., 1. Flags and plates, in nine sorts, price from 6 to 150 marks per lb. (5*s.* 4*d.* to 135*s.* per lb. English). 2. Amber for ornaments and mouthpieces, in seven sorts, from 3 to 60 marks. 3. Light amber in four sorts, from 1·5 to 9 marks. 4. Impure amber, for technical purposes (varnishes, chemicals, &c.), in five sorts, from 2 to 5 marks per lb. Nos. 1 and 2 are chiefly exported to Vienna, France, and Russia. Orders from Eastern Asia have almost entirely ceased. The prices of so varying an article must of course differ very much according to quality; thus, amber of the fine cloudy sort is paid at the rate of 22 thalers (60*s.*) per lb. of nine pieces, whilst 1 lb. of 200 pieces only fetches 3 thalers. The coral or pearl sort is quoted at from 10 to 4 thalers, according to the number of pieces in the lb. (from 30 to 100). The impure *schlaube*, or manufacturing amber, only fetches from 3 to 6 sgr. per lb. (3*d.* to 6*d.* per lb. Engl.) The value of the amber brought to Dantzic—the chief emporium—was estimated at 784,000 marks (£39,200) for 1875. *Zeitschr. für das Berg. Hütten und Salinen-Wein.*

JAPANESE Paper.—In Japan, paper finds a very wide field of usefulness outside of the commoner but perhaps more important applications for writing, printing, wrapping, and wall papers. The peculiar strength and toughness of Japanese paper fits it for many uses which would hardly be anticipated. Japanese paper handkerchiefs, with which we are all familiar, are quite soft and pleasant to use, and at the same time nearly as tough as cloth; and from twisted strips of paper torn from these an excellent string may be extemporized, really quite strong and serviceable. In Japanese houses paper not only covers the walls and ceilings, but is used on the light sliding doors which divide one room from another, and on the folding screens which protect from the too abundant draughts. Light wooden frames, on which a single thickness of paper is stretched, form the windows, admitting light but not sunshine, and air in plenty, but not wind. The paper *shoji*, however, as might be expected, fail completely against rain, and must be supplemented by sliding or outside wooden storm doors. Made waterproof with oil, paper serves for umbrella covers and rain coats, and in large sheets is used to protect baggage and merchandize. In the form of an admirable artificial leather, it is used for pocket-books, boxes, &c. An inferior pasteboard is also made from paper, which is sometimes used for boxes. Thin sheets of wood, however, cut by hand with a large plane, being both cheaper and better, usually replace this material. Articles of papier-mâché are common, but are usually disguised by lacquer, and can hardly be distinguished from ordinary wooden lacquer ware. In the catalogue of the Japanese section at the Philadelphia Exhibition, mention is made of paper mosquito netting, paper garments of various kinds, and of a peculiar paper crape.

Practical Literature.

AUTOBIOGRAPHY OF SIR JOHN RENNIE, F.R.S.[1]

AN apology would be due to our readers for the delay that has taken place in publishing our notice of this book were it not for the fact that a very short time before its appearance, and but a few months after his death, we had already given a biographical sketch and a portrait of this distinguished engineer.[2] The sketch, it will be remembered, dealt simply with the broad outlines of his active and eventful career—so pregnant with important practical results to the entire civilized world; and it is gratifying to note how thoroughly our estimate of his personal character is confirmed by the most interesting and valuable autobiography which now lies before us.

We have, moreover, had the less hesitation in postponing our review of this book, because the subject is one that will not possess attractions to our readers merely on account of its novelty. What we said in the paper already referred to of the elder Rennie, applies with equal force to his distinguished son—his works will better perpetuate his name than "storied urn or animated bust," and the record of his life will, we venture to predict, be read with profit and interest as long as the results of his genius and skill remain to keep his memory alive. In these days, when it can be said with more truth than ever that "of the making of many books there is no end," there is too great a tendency, in the feverish desire for everything that is new, to create an ephemeral interest in almost every fresh subject that presents itself, and this, of course, by its very nature is rapidly exhausted, while the next new book, biography or other, entirely covers up and hides out of sight as it were the one that just preceded it. A new poem by Mr. Tennyson, a volume of Mr. Theodore Martin's "Life of the Prince Consort" is in the reviewers' hands to-day, and, behold! to-morrow morning sees it reviewed at enormous length in nearly all the morning papers; reviews appear in the weekly journals of the following Saturday; such monthly magazines as concern themselves with new books criticize it in their next number; and after the interest has perhaps been lingeringly revived by a notice in the next quarterlies, the book is forgotten, and room is made for the ever-increasing army of new ones, which also appear only to have their brief day and die.

Such a fate, however, we feel confident has not been reserved for the work before us, and one of the reasons which has led us to defer our notice has been, as far as lay in our power, to protest against the unhealthy haste to which we have referred, and to endeavour to keep alive the interest in the work after the first excitement attendant upon its publication has passed away. We do not, however, intend to convey that it needs any such adventitious aid; from what we have already said, our readers will have inferred that we attach no inconsiderable importance to the book. We should like to see a copy of it in the hands of every young engineer and every student, for it contains most excellent advice to engineers commencing their career, while the qualified professional man will find in it many profitable hints in connection with his business, and will derive both pleasure and amusement from its perusal.

This autobiography, as the preface informs us, was written in 1867, shortly after its author had retired from the active duties of his profession, and although it was wholly written from memory, and Sir John was subsequently unable to revise it as he would have desired, few substantial errors are to be found in the work, and it is now presented to the public in its original state, with the exception of such correction as was absolutely necessary. It is as simple, straightforward, and manly an autobiography as we ever remember to have read. His early school life is passed over in a very few sentences; the only remarkable incident connected with it seems to be the fact that for some time Percy Bysshe Shelley was with him at Dr. Greenlaw's school at Isleworth. His school career finished, and the idea of a soldier's life—with which the victories of Wellington and Nelson appear to have fired the mind of all the English youth at that time—abandoned, the basis of his professional education was laid in the only manner in which it can be soundly done—viz., by his actually working in the various branches of practical mechanics, combining with this a course of study of the theoretical portion. The various professional experiences of his early career, and the method by which the more advanced portion of his education was conducted, deserve careful attention by those to whom the education of our young engineers is entrusted. John Rennie's opportunities, with such a man as he had for a father, were of course unique, but the principles which this father wisely allowed to guide him in the education of his son may be applied by all to whom the training of our engineers is committed.

Having now, as he says, "received a tolerably good education, both theoretical and practical, as a civil engineer," his father thought it desirable that he "should travel for a time to study what had been done in ancient and modern times both in architecture and engineering." That portion of the volume which recounts his travels is full of lively interest. He visited Switzerland, Italy, Greece, Asia Minor, Constantinople, and Egypt, and wherever he went he was keenly alive to every opportunity for gaining knowledge on those special subjects which were connected with his profession, while, at the same time, he was largely extending his experience in other directions. He visited all the engineering works of importance, both ancient and modern, and carefully noted their distinguishing features, thus doubtless laying

[1] *Autobiography of Sir John Rennie, F.R.S., Past President of the Institution of Civil Engineers, comprising the History of his Professional Life, together with Reminiscences dating from the commencement of the Century to the present time.* London: E. and F. N. Spon. 1875.

[2] See PRACTICAL MAGAZINE, Old Series, No. 23, November, 1874.

up a store of knowledge which was destined to be of great value to him in his future career. But indefatigable as he was in the pursuit of all matters pertaining to his profession, he did not debar himself from any of the social privileges of which he was enabled to avail himself; for example, while in Rome he made the acquaintance of "that prince of sculptors, Canova," and also of his no less distinguished contemporary Thorwaldsen. Of these he says, speaking first of Canova: "I frequently went to his studio, where he always received me with the greatest kindness. He was then at work on the model of his famous dying Madeleine, which struck me as a masterpiece of elegance and beauty, combined with the resignation and piety which so pre-eminently distinguish it as a beautiful specimen of art. Nobody could be more kind, amiable, and modest in his manner than that distinguished sculptor—flattered by emperors, kings, and the great and cultivated of every land, he never for a moment forgot himself, or appeared to be elated, or to be put out of his simple, unobtrusive manner; whilst to his brother artists he was equally kind and familiar. To his inferiors he was always gentle and considerate, giving his humbler fellow-workers every encouragement and advice, cheering them on their way, and not unfrequently assisting them with his purse when their necessities required it. He was devoted to his art, of which he was so eminent a professor, and with it combined all those amiable and charitable feelings which rendered him a universal favourite and a benefactor to mankind.

"I made acquaintance also with great Dane Thorwaldsen, who frequently admitted me to his studio. He was totally different from Canova. His square, massive head, covered with a redundance of flowing locks; his finely-developed countenance, beaming with talent and firmness of purpose; his colossal and well-proportioned figure, and erect and commanding gait—all combined to raise in the mind of the spectator a degree of respect and admiration not usually to be met with. Yet with all this apparent sternness there was combined a happy mixture of gentleness, genial sociability, and good nature, which, after a little acquaintance, soon made you feel at home with him; the more you knew him the more you liked him. He was then at work upon the colossal figures of the Twelve Apostles, for the church at Copenhagen—a commission given to him by the king. Several of these were finished, and magnificent specimens of art they were."

Such pleasant society did not, however, always lie in his path. Often when travelling he was exposed to serious danger; for in those days some of the countries of Europe, even in the comparatively beaten tracks, were far from safe for travellers. Brigands and wild beasts abounded in some of the places which he visited, and travelling was far from being the easy, comfortable matter that it now is. Frequently he had to rough it, and he relates the following incident, which occurred to him when travelling in Asia Minor:—

"There were only a few scattered, wretched hovels in the vicinity, but none of them fit for our accommodation: I therefore preferred the open air, and determined to bivouac amongst the ruins; as I had already provided myself and my people with mattresses and coverlets and a good supply of provisions, I felt myself comfortable and independent. I was roused about daybreak by something tugging at my pillow; upon jumping up, I descried a large wolf close by, with several more near him. I immediately laid hold of a stout stick and dealt him a heavy blow on the head. This aroused Demetrius and the servants, who fired several shots at the other wolves, and they all scampered off as quickly as possible, so that we had no further molestation."

The death of his father, in 1821, necessitated the return of the son to England, and we now come to that part of his life which was occupied in the construction of those works which have made his name famous, and which he prosecuted with unceasing vigour up to within a very short time of his death. His first ambition was to succeed his father in the numerous great works then being carried on by the Admiralty, such as the Plymouth Breakwater and the new Chatham and Woolwich dockyards. The various enterprises which he undertook and successfully carried into execution have already been enumerated in the article of November, 1874, and we will not, therefore, recapitulate them here. His own descriptions of them are penned with scrupulous minuteness, although never at tedious length, and will well repay careful study. After describing them fully in chronological order, he recounts briefly towards the close of the volume the works which he executed in the course of his professional career. It may almost be said that from the close of his journeyings abroad, prior to 1821, the story of his life is comprised in this record, which, it is curious to note, has been compiled without a single date, note-book, or journal to refer to.

Before leaving the work we should like to return to a subject to which we have already adverted in this notice, and upon which Sir John Rennie has given some excellent advice in the concluding chapters of his autobiography. It is upon the best plan of education for the profession of a civil engineer, and we are quite certain that in giving this extended publicity to these views on the subject, we are doing what would meet with the full approval of their author, who always had the best interests of the profession, at the head of which he so deservedly stood, at heart. After condemning the present system, or rather no system, of educating civil engineers, and pointing out its hurtful results, Sir John Rennie returns to the question "What is the best mode of education for a pupil to obtain the multifarious, and, as I contend, absolutely necessary information, to enable him to practise the profession of a civil engineer in the most enlightened, scientific, and practical manner?" the following answer:—

"Let him first get a sound elementary education in the several departments of arithmetic, algebra, natural philosophy, geography, geology, astronomy, chemistry, land and hydrographical surveying, as well as grammar, English composition, history, French, German, and Latin; according to the improved system of modern education every youth of ordinary talents has a tolerably fair knowledge of these at seventeen or eighteen. Then let him be apprenticed for two or three years to some good steam-engine and machinery manufacturer, where he should learn to make drawings and calculations, handle tools, make models, steam-engine machinery, and put machinery together. By this means, if he applies his mind to it properly, he may become a practical as well as theoretical mechanician, which is the soundest basis for good engineering; indeed, without this, it is impossible for an engineer to be thoroughly successful, but being well-grounded in this most important knowledge, all the others will become comparatively easy. Having gone through this apprenticeship, let him bind himself for three or four years to some well-known civil engineer of large practice in railways, docks, harbours, waterworks, canals, drainage, rivers, &c. In this office the pupil will learn everything connected with these departments; and, as they are founded more or less upon practical mechanics, he will soon find that from his previous mechanical education he has already acquired considerable knowledge of them, and it will be only necessary to apply those principles modified according to the particular circumstances required; in fact, the principles are always the same, although applied upon a larger scale."

We must now leave this most interesting and valuable story of a noble and useful life. It is impossible to estimate the material good which the present generation enjoys from the labours of such men as Sir John Rennie; and, although it is not given to every one to achieve such great results as he has done, we may all of us learn something of practical and moral worth from the pages of this unassuming record of the life and labours of a man of whom every Englishman may be justly proud.

THE ELEMENTS OF GRAPHIC STATICS.[1]

IN the Continent the solution of all kinds of problems by purely graphic methods forms a part of the curriculum of nearly every engineer; and our neighbours have already published many important works on the subject, while in England its value has been acknowledged by but a very few engineers. The late Professor Rankine and Professor Clerk Maxwell have made some valuable contributions to the subject; but it can hardly yet be said to have received the recognition it deserves. The present work has been translated from the German in the hope of making this branch of study more widely known in this country. It is a very complete elementary treatise on the subject, and is thoroughly practical in its character, while the mathematics involved are of an extremely simple character. We have not seen the original German, but we question the advisability of omitting the first portion of it—as the translator confesses to have done—which treated of graphic arithmetic; in our opinion, if it be what it is described, viz., a useful and appropriate introduction to the study of graphic procedure, it is exactly what was needed in order to familiarize the student with the method in its simpler applications.

[1] *The Elements of Graphic Statics.* By Karl Von Ott, Professor an der K. K. Deutschen Oberrealschule, &c. Translated from the German by George Sydenham Clarke, Lieut. R.E., &c., and author of "Practical Geometry and Engineering Drawing." London and New York: E. and F. N. Spon. 1876.